



**american  
academy  
of  
gold foil  
operators**

# Gold Leaf

JUNE 2019

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First class two foils completed by Dr. Robert Bridgeman.



**Welcome...** to the 2019 Annual AAGFO Meeting this year at West Virginia University School of Dentistry located in Morgantown, West Virginia. This year's meeting is extraordinary in that it is a joint meeting with the Academy of RV Tucker Study Clubs. Here you will see some of the finest gold operations found anywhere in dentistry. On behalf American Academy of Gold Foil Operators, I would like to pay special thanks to Drs. Craig, David and Robby Bridgeman and the rest of the Hollenback Medina Club for their gracious hospitality and diligent work to insure an informative and successful meeting. Our Academies owe a great debt of gratitude to the Dean of WVU, Dr. Tom Borgia, as well as the faculty/administration for creating such a welcoming environment and opening their facilities to us. Please note that all meeting information is available for your convenience via links on both academy websites.

I would also like to take a moment and extend an invitation to all our Tucker Academy friends to consider joining the Foil Academy. To have the opportunity to service your castings with foil during study club sessions provides a great benefit to our patients and expands our casting talents. AAGFO applications are available at the registration table.



In 1952, the Summer Olympics, officially known as the Games of the XV Olympiad, were opened in Helsinki, Finland and Dwight D. Eisenhower resigned as Supreme Allied Commander of NATO. That very same year, Dr. Bruce Smith, as the 1<sup>st</sup> President of AAGFO initiated the first Annual Meeting of the Foil Academy. Our Academy is rich in tradition with life long restorations as its core paradigm. Thanks to Dr. David Thorburn, the Academy has secured a dental manufacturer to produce gold foil instruments.

We look forward to exploring all that Morgantown has to offer, see and learn the best that dentistry has to offer, and form lifetime memories at the same time.....

Alfred LaPorta, DDS  
President, American Academy of Gold Foil Operators

## AMERICAN ACADEMY OF GOLD FOIL OPERATORS

### 2019 ANNUAL MEETING

JOINT MEETING WITH THE ACADEMY OF RV TUCKER STUDY CLUBS

SEPTEMBER 4 – 7, 2019

WEDNESDAY – SATURDAY

WEST VIRGINIA UNIVERSITY

MORGANTOWN, WV

REGISTRATION FOR THE MEETING IS GOING TO BE MANAGED BY THE HOSTING ARVT STUDY CLUB. THE WEBPAGE FOR REGISTRATION IS NOW ACTIVE AND CAN BE ACCESSED BY FOLLOWING THE LINK BELOW.

### [AAGFO / ARVTSC COMBINED MEETING REGISTRATION](http://drdavidphelps.com.edit.officite.com/registration.html)

<http://drdavidphelps.com.edit.officite.com/registration.html>

Headquarters Hotel – Marriott Waterfront

Two Waterfront Place

Morgantown, WV 26501

(304) 296-1700



# AAGFO HISTORICAL PRECEPTS

Some of the earliest adopters of direct gold as a restorative material in organized dentistry comes to us through reports by past presidents. In Vol 1 no.1 edition of the AAGFO journal an article coauthored by Ralph E. Plummer DMD, Bruce Smith DDS, and Gerald D. Stibbs, DMD all of Seattle Washington attribute inception of the organization to Dr James Mark Prime (Omaha, Nebraska) as early as 1931. Dr George Hollenbeck and Dr Charles Stebner worked with great discipline and perseverance to ensure rubber dam isolation of the operative site was a clinical imperative and bridge to excellence. I had the rare privilege of once meeting Dr Stebner then in his 80s in the late 1980s at his office in Laramie Wyoming. He would dutifully strap on his hunting boots every morning and run 2 miles through the Red Desert region.. What a dynamic personality.... He gifted me his personal Michigan burnished. Still used and treasured.

At the initial meeting at the Chase Hotel in St Louis, MO, 6:00 pm September 11, 1952; there were 36 men in attendance from various parts of the USA. Representing the Golden Gate Study Club, Dr Harry True said, "It is not good enough unless it is the best we can do"...

The meeting was under the name of "International Society of Gold Foil Operators".... Drs Lester E Myers and Miles Markley (Denver, Colorado) proposed the name change to its current moniker "American Academy of Gold Foil Operators".... the name stuck..

The second meeting was scheduled for Cleveland, Ohio... many of prominence were present for this meeting including Dr George Paffenbarger, Dr G. Ratte (President of the Canadian Dental Association), Dean Harold Noyes of Univ of Oregon, Dean E. Charon faculty Univ of Montreal. Commander Robert Walcott USN reporting on rubber dam use at the Naval Dental School; Bethesda. In fact there was now a standing rubber dam committee headed by Dr Stebner.

The authors close by referring to the minutes of their early meetings saying, "you will find there a history of the unselfish attempt to unite our efforts towards finer dentistry by men from all parts of the United States and Canada."

..."it is our belief that the dentist who does gold foil work believes and practices better dentistry, for he is familiar with the finest margins known to operative dentistry".

We stand on the shoulders of giants. Since those early days we enjoy the accomplishments of both men and women. We have added members around the world and continue to offer encouragement and training through our annual sessions at Colleges of Dentistry and locally through study club work..

I encourage every dentist to explore for themselves the access to better quality dental health through the use of direct gold..

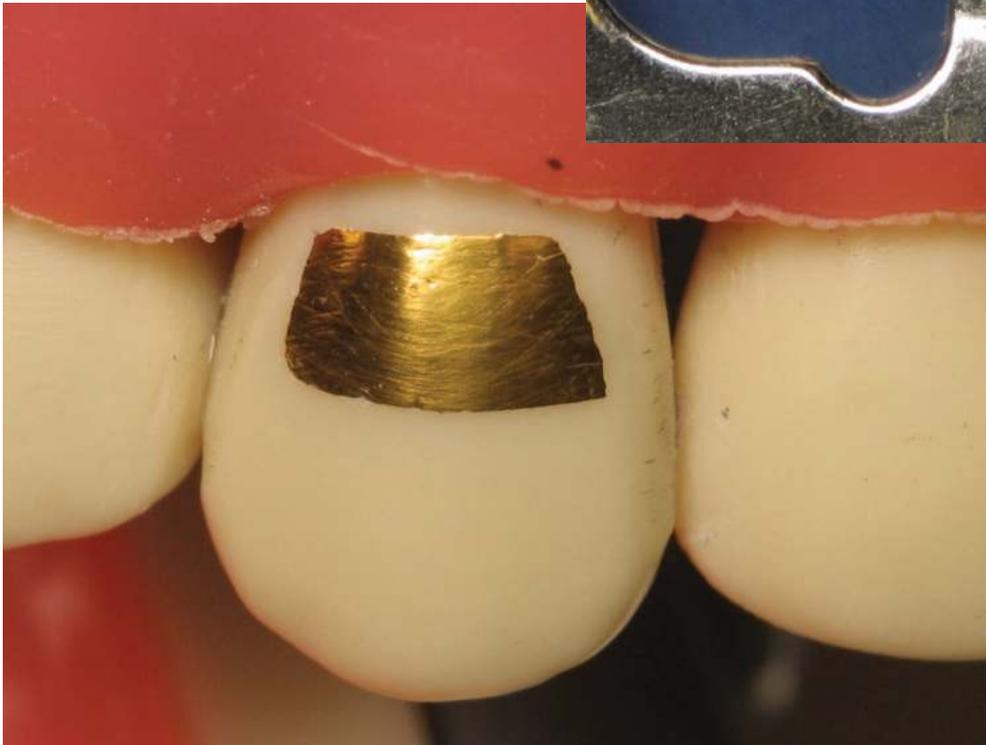
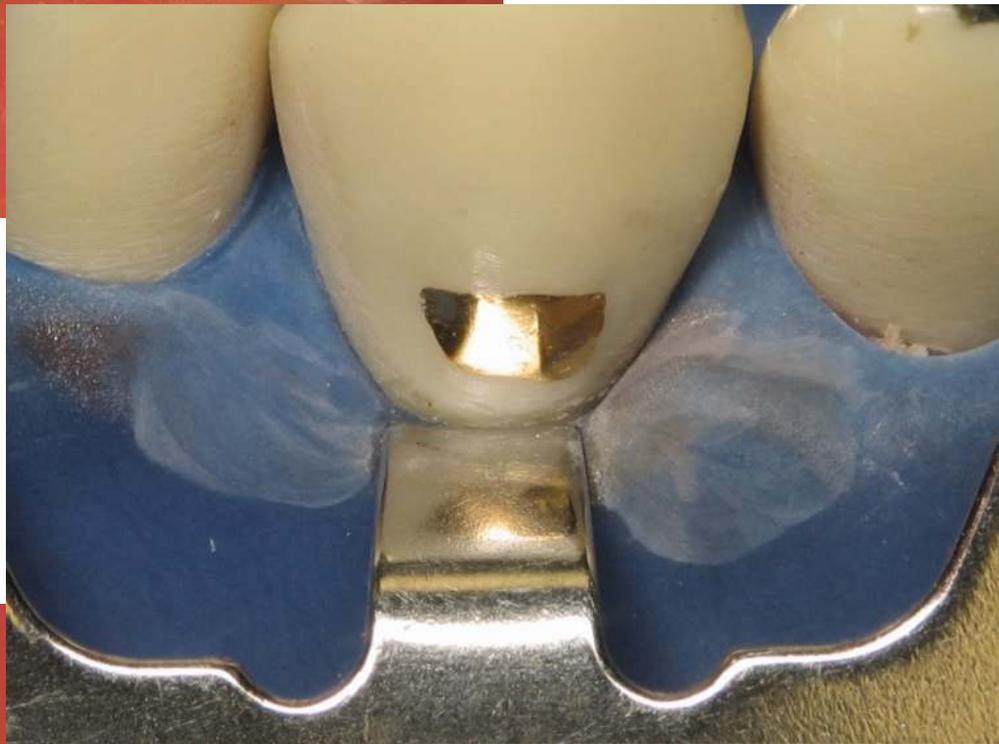
Respectfully submitted 2019  
Richard B Brinker, DMD, MBA



Looking down into Morgantown, West Virginia



Foils completed by  
Loma Linda University  
dental students under  
the guidance of Dr.  
Clyde Roggenkamp.





# A DENTAL STUDENT ON THE VALUE OF GOLD FOIL TRAINING

A phrase I have read growing up, found in the Bible's book of Proverbs (16:16) states "How much better is it to get wisdom than gold!" Gold has been a material recorded throughout history and used in various cultures and widely coveted as a precious metal. In India, where my family originated from, married women wear gold braided necklaces to symbolize wealth and happiness.

During dental school, my first experience working with gold was in the second year with the fabrication of gold crowns in a fixed prosthodontics course. Our assignment after preparing a molar was to make an impression, pour up the stone and wax up the stone die to ideal. Then the next phase was to invest, cast, trim and polish the gold crown before seating it on the die. I heard about an optional gold foil class students could take in their second or third year. I was not sure if I could take another class after already carrying a full schedule. When the opportunity arose, I signed up and went to the first session that took place in the evening after school hours. It would meet for one night a week for several weeks. During that first evening class, I learned about the ancient civilizations' use of gold in dentistry. We also learned about forms of gold such as sheets, powder, and pellets and their properties. We viewed before and after photos of gold foil repairs on gold cast crowns, inlays, onlays, and gold foil fillings. They were truly works of art.

Throughout the course we learned the benefits of using this material and compared it to other commonly used restorative materials. Then we continued to expand our knowledge by learning preparation principles, instrument uses, annealing the gold foil pellets, condensation techniques, and polishing. Our experienced faculty, who volunteered their time and energy, were dedicated and passionate in sharing their knowledge and experience with us. At the end of the course, a gold foil certificate of completion was presented to each of us and we were encouraged to utilize this procedure in clinical settings with our patients as needed.

As a new grad, I look back on this course fondly. As an optional class, it was more enjoyable since the students there wanted to be there and were not forced. As a result there was less complaining when difficulties arose, especially in condensation technique, which proved the most difficult part of the procedure for many of us. The faculty truly care about each of us learning and were excited to share their knowledge on the topic. I was impressed at the restorations that were shown done over 40 years ago that were still in pristine condition with no discolored or defective margins. I began to discuss treatment plans with gold foil as a restorative option with patients when the opportunity arose and did a gold foil restoration on clinic with a certified faculty member.

I am very grateful for the opportunity to take this course and for the dedication of my faculty to teach this valuable information. In the future, I hope to use this skillset to provide patients with an alternative to other commonly used restorative materials. It would be incredible to see during my career as a dentist, a gold foil restoration that I have done, last half a century or more for a patient.

Jenifer E. Jesson, DDS, MPH  
Loma Linda University



# AAGFO EXECUTIVE COUNCIL MEETING

FEBRUARY 20, 2019

THE DRAKE HOTEL, CHICAGO, IL

## AGENDA

(Astor Room 2:00 – 5:00)

**Call to Order:** Dr. Alfred LaPorta (President)

**Minutes of the Seattle October 24, 2018 Annual Meeting Executive Council:** Dr. Marc Tollefson

**Secretary's Report:** Dr. Tollefson/ Dr. Morrison; necrology

**Treasurer's Report:** Dr. Barry Evans

**Meeting Planner:** None

### Annual Meetings:

- 1- **2018 Seattle, WA Annual Meeting Report:** Dr. Dick Tucker
- 2- **2019 (joint meeting with ARVTSC) Annual Meeting Report, WVU Morgantown WV:** Dr. Craig Bridgeman, Dr. Dave Bridgeman, Dr. Robbie Bridgeman
- 3- **2020 Annual Meeting:** Dr. Tim Carlson, Indiana University
- 4- **2021 Annual Meeting:** Dr. Dave Thorburn, Vancouver UBC

**Journal of Operative Dentistry Report:** Dr. Jeff Platt, Editor; Dr. Tim Carlson

### Committee Reports:

- 1- **Nominating Committee:** Dr. Wendell Foltz, Dr. Suzanne Grennell, Dr. Bruce Small
- 2- **Constitution and Bylaws Committee:** Dr. Barry Evans
- 3- **Scientific Sessions Committee:** (President-Elect) Dr. Robert Bridgeman
- 4- **Literature and Research Committee:** Dr. Tim Carlson
- 5- **Education and Clinical Seminars Committee:** Drs. Thorburn, D. Bridgeman, B. Small
- 6- **Other Committees:**
  - A) **Inter-Academy Liaison Committee:** Drs. Alfred LaPorta, R. Bridgeman, Marc Tollefson (Pres, Pres-Elect, Secretary)
  - B) **Distinguished Member Award Committee:** Drs. T. Carlson, W. Foltz, D. Henry
  - C) **Clinician of the Year Award:** Drs. B. Small, T. Bollerman, A. LaPorta
  - D) **Forward Looking Committee:** Dr. Alfred LaPorta

**IAGFO Report:** Dr. Wendell Foltz, Dr. Warren Johnson

**Gold Leaf:** Dr. Dan Henry (Editor) - encourage clinical foil photo submission

**Website:** Dr. Scott Barrett (Webmaster)

### Old Business:

- 1- **Instruments:** Dr. Thorburn (ongoing discussions with DenMat/Hartzell; AAGFO to purchase for student kits for the WVU Annual Meeting)

### New Business:

- 1- **AAGFO Table Clinic Update:** Dr. LaPorta

### Adjournment:





Foils completed by  
Loma Linda University  
dental students under  
the guidance of Dr.  
Clyde Roggenkamp.





# SECRETARY'S REPORT AAGFO

## CHICAGO MIDWINTER MEETING—DRAKE HOTEL

### FEBRUARY 20, 2019

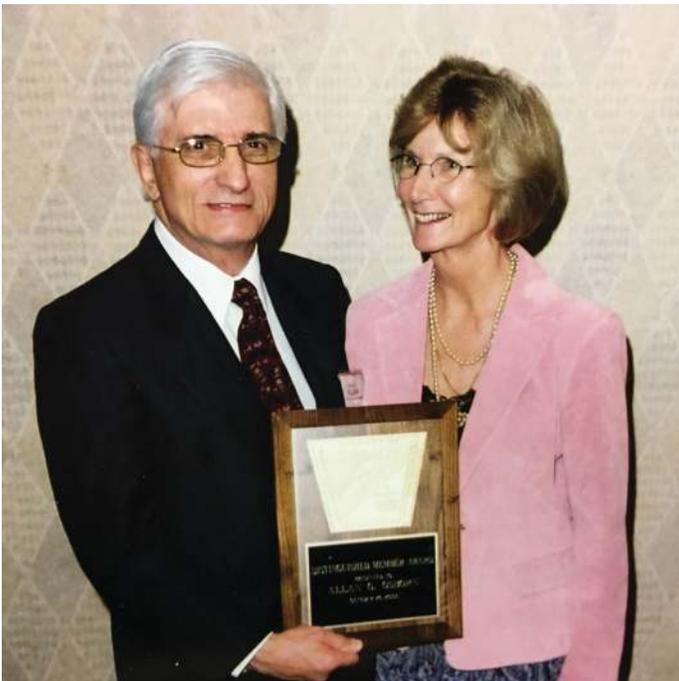
On January 15 I sent notification of our student awards program to all participating dental schools. So far, I have had one response with their candidate and time of their award ceremony. It is still a bit soon to receive responses from the schools so more will be forthcoming.

Usually all Academy correspondence is now done through emails to my address and not through regular mail. Since our last meeting there have been only a couple requests to find dentists that can place foils in a particular geographic area. I've given them contact people in that area from membership to help them. We are fewer in number now and even fewer in current operators. We have lots of retired and life members as you know.

I will be working with Dr. Eric Morrison in the following months in the secretarial duties to bring him up to speed as our new Secretary for 2019. Thank you Council for the honor of serving you these past 6 years. Gold foil has always been highlight and touchstone in all of my 42 years of practice.

Marc Tollefson DDS.  
Secretary AAGFO

It is with sadness that I present the obituary for our friend and colleague Dr. Allan Osborn:



I have never had the pleasure of meeting Dr. Allan Osborn, but I feel I know him through the loving stories shared by his family and friends. He had an impressive career with an endless list of accomplishments. When Allan passed, he was an active member of the Canadian Dental Association, Canadian Academy of Gold Restorative Dentistry and Prosthodontics, American Academy of Gold Foil Operators, Associated Ferrier Study Clubs, Academy of Tucker Study Clubs, The Winnipeg Ferrier Society, and American Academy of Restorative Dentistry.

Allen was born in Mount Vernon, New York on October 20<sup>th</sup>, 1935, and moved to Derby, England when he was three years old. He attended Sheffield University Dental School and



graduated in 1960 with his BDS degree. After graduation, Allen's thirst for knowledge continued, and he enrolled in a one year postgraduate Orthodontic and Oral Surgery program. He moved to Canada in 1962 and was unable to find work in a traditional dental practice setting. He spent the next two years working on the indigent population including four months aboard the icebreaker C.D. Howe.

In 1967, Allan found his passion when he enrolled in a two-week Ferrier gold foil course given by Dr. Gerry Stibbs who became one of Allan's earliest mentors. Soon after attending the class, Allan founded the Winnipeg Ferrier Society, mentoring hundreds of dentists over more than 20 years. In 1976, he was asked to instruct a two-week Ferrier Gold Foil course with the founding father of the AAGFO, Dr. Bruce Smith, and his fate was sealed. Allan went on to become the president of the organization, the editor of the academy's newsletter for 24 years and received The Distinguished Member award from The American Academy of Gold Foil Operators in 2006. Because of his unselfish dedication to dentistry, Allan was honored to serve as the president of the Canadian Academy of Restorative Dentistry and Prosthodontics in 2005. However, Allan's wife, Hazel said his highest honor in dentistry was becoming a member of the American Academy of Restorative Dentistry in 1984. "It was always his goal to be a member of the AARD," she said.

In addition to Allen's professional accomplishments, he lived a full and balanced life with his wife Hazel and their two daughters Louise and Andrea. Hazel described him as a genius with an upbeat personality and a man of integrity, who held those around him to the same standards. Allen wanted to help people succeed and had the unique ability to make people smile. His interests outside of dentistry included playing and refereeing rugby, holding a Black Belt in Gung-Fu, playing the piano, and speaking German, French, and Japanese. Hazel said the love of his life, besides her of course, was his 750 Kawasaki motorcycle. He loved taking long rides in the country.

Allen's contributions to his family, friends, and dentistry will never be forgotten. When our time is up, we can only hope we can claim half the accomplishments of Allen. Maybe then, someone will honor us by saying we lived life like fellow American Academy of Restorative Dentistry's Dr. Allen Osborn.

Respectfully Submitted,  
Curt W. Ringhofer, DDS

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The paper that begins on page 10 is presented by Dr. Lai-Sheng Wang and published in the Journal of Physical Chemistry Chemical Physics. [www.org/pccp](http://www.org/pccp).

I would like to thank Dr Wang and the Journal PCCP for permission to reprint this paper here.

This is a very interesting paper discussing the relativistic effects demonstrated in the gold atom caused by the fact the gold atom is missing an electron in its outer shell. The relativistic effects lead to a destabilization of the 5d orbitals, reducing the 6s-5d energy gap giving the gold atom its significant covalent bonding characteristics. This could explain the bactericidal effect we see with gold in restorative dentistry caused by the oligodynamic effect of gold on bacteria in the immediate area.

The oligodynamic effect is the denaturing of proteins within the cell membrane of target cells by binding to reactive groups and is demonstrated by metals such as gold, silver and copper.

The relationship of the relativistic effects with the oligodynamic effect might be a leap. However, the paper is a very good read and opens new knowledge of the material we all use.

Dan Henry DDS

# Covalent gold

Lai-Sheng Wang

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Gold is known to be the noblest of all metals because of the relativistic stabilization of its outer 6s orbital. The relativistic effects also lead to destabilization of the 5d orbitals, reducing the 6s-5d energy gap and enhancing s-d hybridization. Therefore, in contrast to its lighter congeners, gold exhibits significant covalent bonding characters and a remarkable repertoire of chemistry, which are increasingly being exploited in catalysis and nanotechnology. This Perspective presents a brief account of recent experimental efforts in the author's laboratory using photoelectron spectroscopy that lead to direct observations of covalent bonding in several relatively simple Au compounds: Au oxides ( $\text{AuO}^-$  and  $\text{AuO}_2^-$ ), sulfides ( $\text{AuS}^-$  and  $\text{AuS}_2^-$ ), and the well-known  $\text{Au}(\text{CN})_2^-$  complex. In a series of Au-Si and Au-B mixed clusters, it has also been found that gold atoms behave like H atoms, forming auro-silicon and auro-boron clusters with strong covalent bonding, analogous to the corresponding silicon and boron hydrides, such as the tetrahedral auro-silane ( $\text{SiAu}_4$ ) versus silane ( $\text{SiH}_4$ ).

## 1. Introduction

Gold possesses a valence electron configuration of  $5d^{10}6s^1$  with a filled 5d shell and a 6s shell similar to the alkali atoms. However, gold displays a "relativistic maximum"<sup>1</sup> that results in some unusual physical and chemical properties for the noblest of all metals. The relativistic effects significantly stabilize the 6s orbital, resulting in an anomalously high ionization potential (9.225 eV) and an extremely high electron affinity (2.309 eV) for the gold atom. On the Pauling scale, the electronegativity of gold, the highest among the metallic elements, is 2.4, which is the same as Se and close to that of

S (2.5) and I (2.5). Thus, even ionic compounds, in which gold acts as an *electron acceptor*, are known, such as in  $\text{CsAu}$  ( $\text{Cs}^+\text{Au}^-$ ). The relativistic effects also destabilize the 5d orbitals, leading to a reduction of the s-d energy gap, and thus endow gold with its enchanting color, which has fascinated humankind since the ancient. Hence, despite the fact that gold is known to be the noblest of all metals, it exhibits strong covalent bonding characters due to s-d hybridization and displays a remarkable repertoire of chemistry.

The chemistry of gold is undergoing a renaissance because of the increasingly important roles gold plays in catalysis and nanotechnology. The covalent bonding nature of gold is at the core of ligand-protected gold nanoparticles and homogeneous catalyses of organogold. Numerous reviews have appeared on various aspects of gold chemistry.<sup>2-5</sup> The extensive theoretical and experimental literature on gold up to 2007 has been summarized comprehensively by Pyykkö in a trilogy of reviews.<sup>6-8</sup> The relativistic effects in gas-phase ion chemistry were reviewed by Schwarz.<sup>9</sup> The interactions between thiolate ligands and gold are critical to self-assembled monolayers and ligand-protected gold nanoparticles. Both experimental and theoretical studies have shown that the ligands adsorb on atop positions with significant covalent bonding between the thiolate and the substrate.<sup>10-14</sup> Even the highly electronegative Cl atoms on Au surfaces have been found to exhibit significant covalent bonding with the substrate.<sup>15</sup> In the past decade, homogeneous Au catalysis for efficient and selective activation of C-C  $\pi$  bonds has undergone rapid development and has been widely reviewed.<sup>4,5</sup> The nature of the Au-C bond has received particular attention.<sup>16-20</sup> The discovery of heterogeneous catalysis by supported gold nanoparticles<sup>21</sup> has stimulated a flurry of activities both in catalysis and in cluster science to elucidate the nature of the catalytic mechanisms.<sup>3,22,23</sup> Novel structures of gold clusters, as a result of the s-d hybridization, have been observed.<sup>24-27</sup>

This Perspective focuses on recent experimental efforts in the author's laboratory using photoelectron spectroscopy

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Lai-Sheng Wang

Lai-Sheng Wang received his PhD from the University of California at Berkeley. After a postdoctoral stay at Rice University, he took a joint position between Washington State University and Pacific Northwest National Laboratory in 1993, then moved to Brown University as Professor of Chemistry in 2009. His research focuses on the investigation of the fundamental behaviors of nanoclusters using photoelectron spectroscopy. Research in his group

has led to the discovery of golden buckyballs and golden pyramids, as well as aromatic clusters and planar boron clusters. His group has also pioneered spectroscopic studies in the gas-phase of free multiply-charged anions and complex solution-phase anions, such as metal complexes, redox species, and biologically-relevant molecules.

(PES) to investigate the electronic structures and chemical bonding of several relatively simple Au-containing molecules and binary Au alloy clusters, in which significant covalent bond characters of Au have been observed. Specifically, three classes of species will be discussed: (i) gold oxides ( $\text{AuO}^-$  and  $\text{AuO}_2^-$ ) and sulfides ( $\text{AuS}^-$  and  $\text{AuS}_2^-$ ); (ii) gold as hydrogen in Au–Si and Au–B binary clusters; and (iii)  $\text{Au}(\text{CN})_2^-$ . PHS involves electron removals from valence molecular orbitals and provides direct information about the nature of the chemical bonding. The covalent nature of the Au–O and Au–CN bonding is directly revealed in the PES spectra. In conjunction with theoretical calculations, the structures and chemical bonding can be investigated in great detail. In a series of Au–Si and Au–B clusters, we have found that Au behaves like H, forming strong auride covalent bonds and yielding cluster structures analogous to the corresponding hydrides.

## 2. Covalent bonding in Au oxide and sulfide molecules

The Au–O and Au–S interactions are essential in nanogold catalysis and ligand-protected gold nanoparticles, for which mono-gold oxide and sulfide clusters can serve as the simplest molecular models. However, except for a few theoretical and spectroscopic studies on the diatomic  $\text{AuO}$ ,<sup>28–32</sup> there was limited knowledge about the  $\text{AuO}_2$  or the sulfide systems.<sup>33</sup> Although there were early matrix studies on the  $\text{AuO}_2$  complex,<sup>34–38</sup> we now know that Au or Au<sup>+</sup> can only form weakly bound van der Waals complexes with  $\text{O}_2$  or the linear dioxide molecules via the reaction of  $\text{AuO} + \text{O}$ .<sup>39,40</sup> A combined PES and *ab initio* study on  $\text{AuO}^-$  and  $\text{AuO}_2^-$  and their valent isoelectronic  $\text{AuS}^-$  and  $\text{AuS}_2^-$  species was carried out to probe their electronic structure and to elucidate the Au–O and Au–S chemical bonding.<sup>41</sup> Vibrationally-resolved PES spectra were obtained at different photon energies, providing a wealth of electronic structure information for each species. Similar spectra were observed for  $\text{AuO}^-$  and  $\text{AuS}^-$  and for the linear  $\text{OAuO}^-$  and  $\text{SAuS}^-$  species. High-level *ab initio* calculations (Table 1) were conducted to aid spectral assignments and provide insight into the chemical bonding in the  $\text{AuX}^-$  and  $\text{AuX}_2^-$  ( $\text{X} = \text{O}, \text{S}$ ) molecules. Configuration interactions and spin orbit couplings were shown to be important and were necessary to achieve good agreement between theory and experiment. Strong covalent bonding was found in both the  $\text{AuX}^-$  and the  $\text{XAuX}^-$  species with multiple bonding characters.

### 2.1 Multiple bonding in $\text{AuO}^-$ and $\text{AuS}^-$

Fig. 1 shows the vibrationally-resolved PES spectra of  $\text{AuO}^-$  at three different detachment photon energies.<sup>41</sup> The spectra of  $\text{AuS}^-$  are similar to those of  $\text{AuO}^-$ . The high photon energy spectrum at 193 nm revealed electron detachments from 5d-based molecular orbitals (MOs) and was important in elucidating the nature of the Au–O bonding. Fig. 2 displays the MO diagram for  $\text{AuO}^-$  and  $\text{AuS}^-$  and Fig. 3 shows the MO pictures for  $\text{AuO}^-$ . The O  $p_{x,y}$  orbitals and Au  $5d_{xz,yz}$  orbitals form the bonding  $\pi$  (HOMO-3) and antibonding  $\pi^*$  HOMO, which are both fully occupied in the anionic ground state. The O  $p_z$  orbital interacts with the Au  $6s$  and  $5d_{z^2}$

**Table 1** Summary of the ground state properties obtained at the CCSD(T) level of theory for  $\text{AuX}_{1,2}^-$  ( $\text{X} = \text{O}, \text{S}$ ) and the measured electron affinities (EA) for the corresponding neutral molecules. All energies are given in eV and bond lengths ( $r_{\text{Au-X}}$ ) are in Å

	State	$r_{\text{Au-X}}$	$D_e(\text{X})^a$	EA
$\text{AuO}$	$C_{\infty v}$ $^1\Sigma^+$	1.882	2.082	$2.378 + 0.015$
$\text{OAuO}$	$D_{\infty h}$ $^3\Sigma_g^+$	1.847	4.046	$3.40 + 0.03$
$\text{AuS}^-$	$C_{\infty v}$ $^1\Sigma^+$	2.216	2.677	$2.475 \pm 0.015$
$\text{SAuS}$	$D_{\infty h}$ $^3\Sigma_g^+$	2.202	3.388	$3.42 + 0.03$

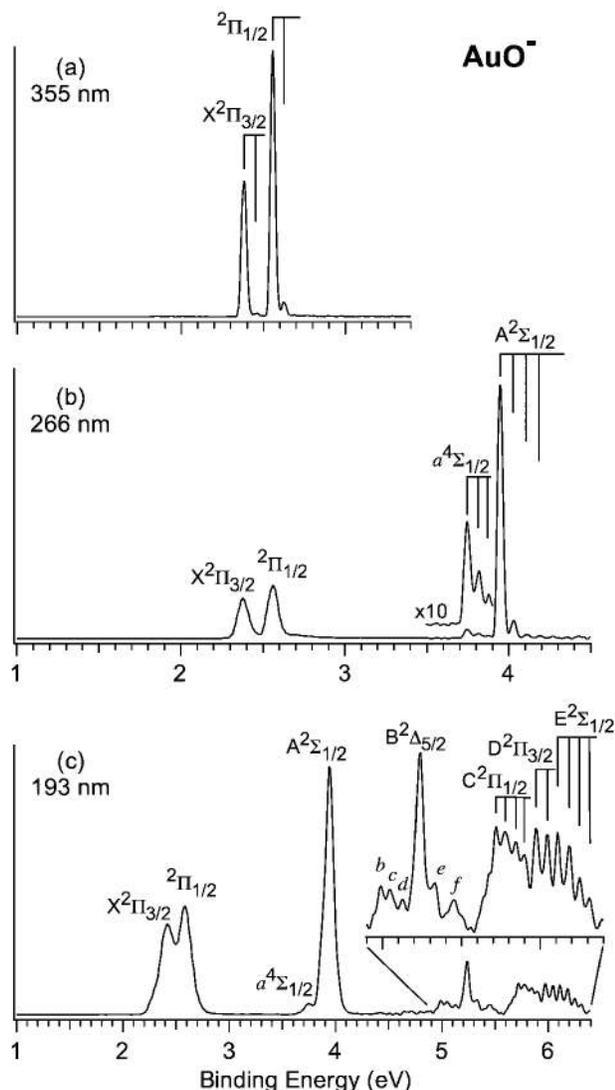
<sup>a</sup> Dissociation energy for the most stable fragments regardless of spin, defined as:  $E(\text{AuX}_n^-) - [E(\text{AuX}_{n-1}^-) + E(\text{X})]$  with  $n = 1, 2$  and  $\text{X} = \text{O}, \text{S}$ .

orbitals to form the bonding  $1\sigma$  (HOMO-4), non-bonding  $2\sigma$  (HOMO-1) and the unoccupied antibonding  $\sigma^*$  LUMO, whereas the  $\delta$  MO (HOMO-2) is purely nonbonding. The X and A bands in Fig. 1 correspond to electron detachments from the O2p-based  $\pi^*$  and  $2\sigma$  MOs, respectively, and the B band corresponds to electron detachment from the  $\delta$  MO. The C/D and E bands derive from detachments from the Au5d-based  $\pi$  and  $1\sigma$  MOs, respectively. The extensive vibrational structures associated with these bands provide direct spectroscopic evidence that the  $1\sigma$  and  $\pi$  MOs are strongly bonding orbitals. On the other hand, the PES spectra for  $\text{CuO}^-$  display no such vibrational activities for detachments from similar MOs because they are non-bonding.<sup>42</sup>

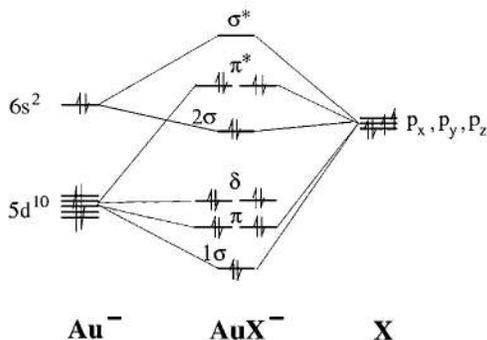
The nonbonding nature of the  $2\sigma$  and  $\delta$  MOs in  $\text{AuO}^-$  is confirmed by the PES spectra in Fig. 1, which show very little Franck Condon activity upon electron removals from these MOs. Thus, on the basis of the MO configuration (Fig. 2), the  $\text{AuX}^-$  molecules possess a single  $\sigma$  bond derived from the  $1\sigma$  bonding MO because the bonding  $1\pi$  and the antibonding  $\pi^*$  MOs cancel each other. However, while the strong bonding nature of the  $1\sigma$  and  $1\pi$  MOs are confirmed by the PES spectra (strong Franck Condon activities), the  $\pi^*$  HOMO is somewhat nonbonding as evidenced by the very weak Franck Condon activities in the spin orbit split X bands (Fig. 1a). Thus, the  $\text{AuX}^-$  species contain some  $\pi$  bonding character. If the  $\pi^*$  HOMO were completely nonbonding, the bond in  $\text{AuX}^-$  could be characterized as a triple bond. Indeed, the calculated bond lengths of  $\text{AuX}^-$  (Table 1) are only slightly smaller than the sums of the Au and X triple bond covalent radii proposed by Pyykkö *et al.* (1.76 Å for  $\text{AuO}$  and 2.18 Å for  $\text{AuS}$ ).<sup>43</sup> Since the  $\pi^*$  HOMO does have some antibonding character, the chemical bond in  $\text{AuX}^-$  is less than a triple bond. Removing the four  $\pi^*$  electrons would lead to a real triply bonded  $\text{AuX}$  diatomic species, which corresponds to the electron configuration of  $\text{AuC}^{\cdot+}$  or  $\text{AuSi}^{\cdot+}$ . Indeed, these species have been predicted previously as containing a triple bond.<sup>44</sup>

### 2.2 Covalent bonding in $\text{AuO}_2^-$ and $\text{AuS}_2^-$

The  $\text{Au}^-$  atomic anion does not react with  $\text{O}_2$  and they can only form a weakly bonded van der Waals complex,  $\text{Au}^-(\text{O}_2)$ , which has been recently reported.<sup>39,40</sup> On the other hand,  $\text{Au}^-$  forms a relatively strongly bonded  $\text{Au}^-(\text{S}_2)$  complex with a substantial binding energy (1.4 eV), which was observed in our laser vaporization cluster source as a minor isomer.<sup>41</sup>

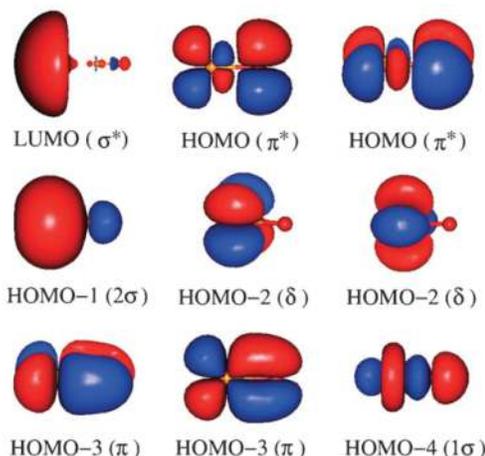


**Fig. 1** Photoelectron spectra of  $\text{AuO}^-$  at (a) 355 nm (3.496 eV), (b) 266 nm (4.661 eV), and (c) 193 nm (6.424 eV). The vertical lines represent the resolved vibrational structures. The detailed assignments are given in ref. 41.



**Fig. 2** Molecular orbital diagram for  $\text{AuO}^-$  and  $\text{AuS}^-$ .

However, Au can form stable linear dioxide and disulfide molecules ( $\text{XAuX}^-$ ) by reactions of  $\text{AuX}^-$  with the atomic species (X). Vibrationally resolved PES spectra at different photon energies were obtained for  $\text{AuX}_2^-$  and their structures



**Fig. 3** Molecular orbital pictures for  $\text{AuO}^-$ .

and chemical bonding were analyzed by comparing with *ab initio* calculations.

Fig. 4 shows the MO diagram of  $\text{AuO}_2^-$  and  $\text{AuS}_2^-$ ; and Fig. 5 displays the MO pictures of  $\text{AuO}_2^-$ . The bonding in  $\text{SAuS}^-$  is very similar to that in  $\text{OAuO}^-$  with nearly identical MO pictures. The O(S)  $p_{x/y}$  orbitals interact with the Au( $5d_{yz}, 5d_{xz}$ ) orbitals to form the strongly bonding  $1\pi_g$  HOMO-5, the non-bonding  $1\pi_u$  HOMO-1, and the antibonding  $2\pi_g$  HOMO. The  $2\pi_g$  HOMO is half-occupied, resulting in the triplet ground state for  $\text{AuX}_2^-$  ( $^3\Sigma_g^-$ , Table 1). The interactions of O(S)  $p_z$  with Au 6s and  $5d_{z^2}$  yield the strong bonding  $1\sigma_g$ , the bonding  $2\sigma_g$ , the weakly bonding  $1\sigma_u$ , and the antibonding  $\sigma_g^*$  LUMO. The antibonding character of the  $2\pi_g$  HOMO was confirmed by observation of substantial Franck–Condon activities in the PES spectra of  $\text{AuX}_2^-$  and the increased Au–X stretching vibrational frequency in the neutrals compared to the anions. The  $1\pi_u$ ,  $2\sigma_g$ , and  $1\sigma_u$  MOs are basically nonbonding according to the PES spectra since there is very little Franck–Condon activity upon electron removals from these orbitals. Thus, the Au–X bonding in  $\text{AuX}_2^-$  should also have substantial multiple bonding characters.

Interestingly, the Au–X bond is significantly strengthened in  $\text{AuX}_2^-$  compared to that in the  $\text{AuX}^-$  diatomics, as seen in Table 1. In particular, the dissociation energy of 4.046 eV for  $\text{AuO}_2^- \rightarrow \text{AuO}^- + \text{O}$  is almost twice as large as the  $\text{AuO}^-$  dissociation energy (2.082 eV for  $\text{AuO}^- \rightarrow \text{Au}^- + \text{O}$ ). This enhanced Au–X bonding in  $\text{AuX}_2^-$  is also reflected in their shortened Au–X distances (Table 1). The enhanced Au–X bonding in  $\text{AuX}_2^-$  is most likely due to the partially occupied  $2\pi_g$  antibonding orbitals, as well as from the strong covalent bonding interactions between the Au 5d and O(S) p atomic orbitals embodied in the  $1\sigma_g$  and  $1\pi_g$  MOs (Fig. 5). Overall, the Au–O and Au–S bonds in the  $\text{AuX}^-$  and  $\text{AuX}_2^-$  molecules are strongly covalent with multiple bond characters due to the s–d hybridization.

### 3. Au as H in Au–Si and Au–B alloy clusters

The isolobal analogy between a gold phosphine unit ( $\text{AuPR}_3$ ) and a hydrogen atom have been well recognized in

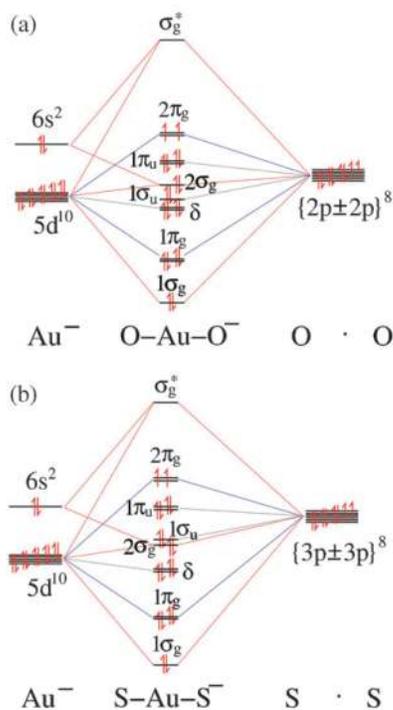


Fig. 4 Molecular orbital diagram for  $\text{AuO}_2^-$  and  $\text{AuS}_2^-$ .

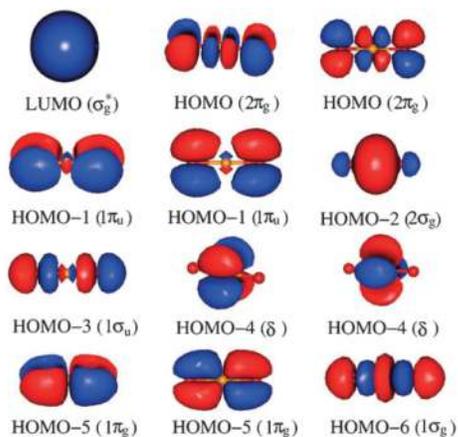


Fig. 5 Molecular orbital pictures for  $\text{AuO}_2^-$ .

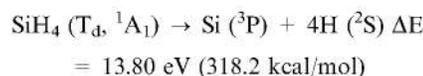
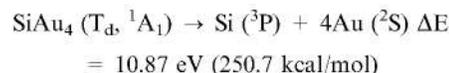
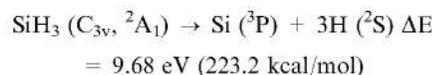
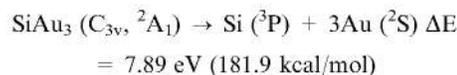
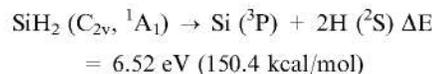
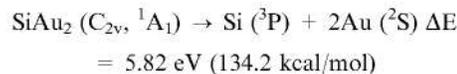
organometallic chemistry,<sup>45–47</sup> such as in the tetra- and hypercoordinate compounds,  $\text{C}(\text{AuPR}_3)_4$  and  $\text{C}(\text{AuPR}_3)_5^+$ .<sup>48,49</sup> The  $\text{Au}^+$  cation has been found to act like a “big proton” in a number of gas phase ion-molecule complexes.<sup>9</sup> In a PES study of mono-silicon gold alloy clusters ( $\text{SiAu}_n^-$ ,  $n = 2-4$ ),<sup>50</sup> we found serendipitously that the Au atoms behave like H atoms in the mixed clusters, resulting in structures analogous to silicon hydrides ( $\text{SiH}_n$ ,  $n = 2-4$ ). The silicon tetraauride ( $\text{SiAu}_4$ ), which was considered in a prior computational study,<sup>51</sup> is found to be particularly stable with a large HOMO–LUMO gap similar to silane  $\text{SiH}_4$ . Molecular orbital analyses showed that Si and Au form strong single covalent bonds in these clusters with bonding energies very close to the corresponding Si–H bonds. Both PES and theoretical studies revealed that larger Si–Au alloy clusters are also similar to the corresponding silicon hydrides. It was further found that Au

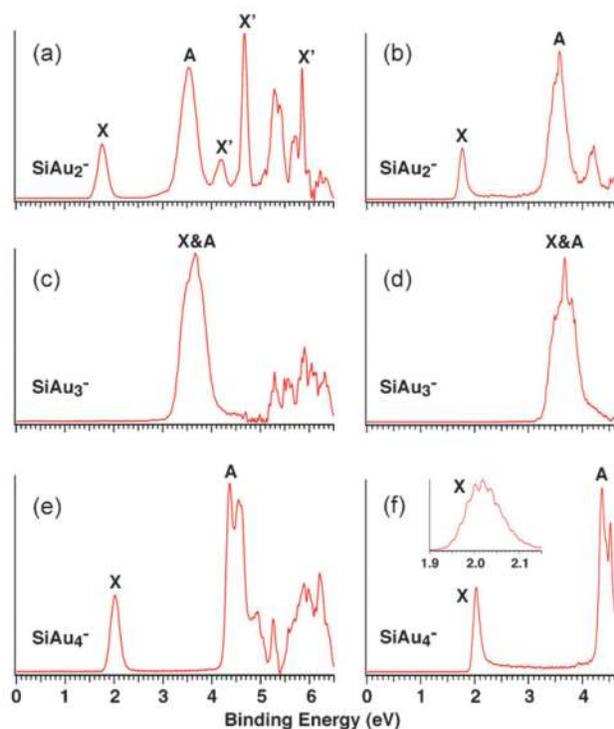
and boron form binary clusters, in which Au also behaves like H. Based on this finding, a series of deltahedral closo-auraboranes ( $\text{B}_n\text{Au}_n^{2-}$ ,  $n = 5-12$ ) in analogy to the well-known deltahedral closoboranes ( $\text{B}_n\text{H}_n^{2-}$ ) have been predicted, which may be viable for chemical syntheses.

### 3.1 $\text{SiAu}_n^-$ and $\text{SiAu}_n$ ( $n = 2-4$ )

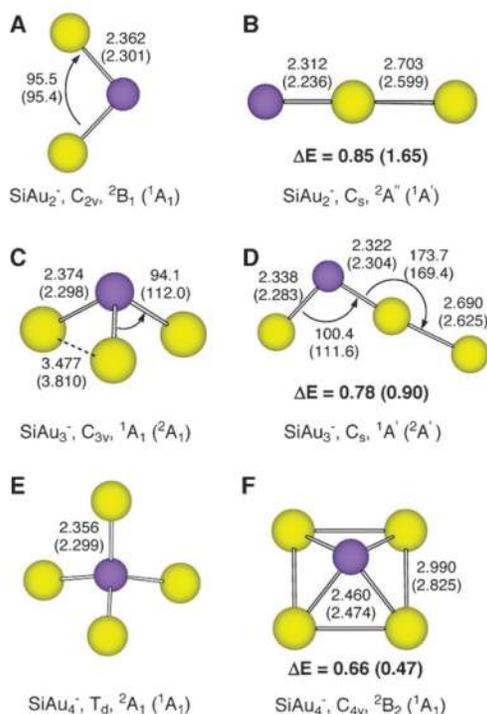
The PES spectra of  $\text{SiAu}_n^-$  ( $n = 2-4$ ) are given in Fig. 6 at two detachment photon energies.<sup>50</sup> The most interesting observation was the extremely large energy gap between the X and A bands observed in the spectra of  $\text{SiAu}_4^-$  (Fig. 6e and f), suggesting a highly stable neutral  $\text{SiAu}_4$  species with a large HOMO–LUMO gap. The ground state transition of  $\text{SiAu}_4^-$  was vibrationally resolved, consisting of a single vibrational progression with a spacing of  $140 \pm 30 \text{ cm}^{-1}$  (inset, Fig. 6f). This observation indicated that the  $\text{SiAu}_4^-$  anion and  $\text{SiAu}_4$  neutral must possess relatively high symmetries. Theoretical calculations showed that the most stable structures of  $\text{SiAu}_4^-$  and  $\text{SiAu}_4$  are both tetrahedral, as shown in Fig. 7e. The simulated PES spectrum of the tetrahedral  $\text{SiAu}_4^-$  agrees well with the experimental spectra, lending strong support for the global minimum structures found for the  $\text{SiAu}_4^-$  anion and its neutral. The tetrahedral structure, in which there is no Au–Au bonding, is much more stable than the square-pyramidal structure (Fig. 7f). Further calculations showed that the most stable structures of  $\text{SiAu}_3^-$  and  $\text{SiAu}_2^-$  and their neutrals are  $C_{3v}$  and  $C_{2v}$ , respectively, which can be viewed simply as removing one and two Au atoms from the  $T_d$   $\text{SiAu}_4^-$  (Fig. 7a and c), respectively.

Remarkably, the global minimum structures of the mono-silicon aurides,  $\text{SiAu}_n$  ( $n = 2-4$ ), are all similar to those of the silicon hydrides,  $\text{SiH}_n$  ( $n = 2-4$ ). As shown in Fig. 8, MO analyses revealed that the chemical bonding in  $\text{SiAu}_n$  are also similar to the corresponding  $\text{SiH}_n$  molecules, suggesting that Au behaves like a H in the auride clusters by forming a single Si–Au covalent bond. To evaluate the stability of the new silicon auride molecules, their atomization energies [at CCSD(T) level] were calculated and compared to the corresponding silicon hydrides:<sup>50</sup>

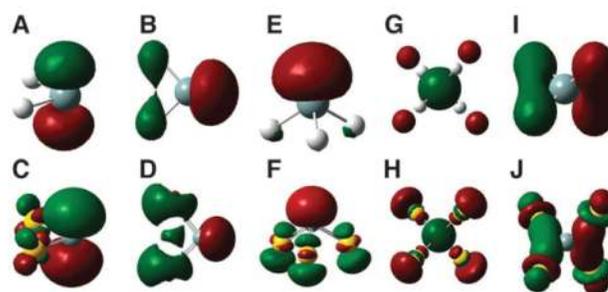




**Fig. 6** Photoelectron Spectra of  $\text{SiAu}_n^-$  ( $n = 2-4$ ). (a)  $\text{SiAu}_2^-$  at 193 nm. (b)  $\text{SiAu}_2^-$  at 266 nm. (c)  $\text{SiAu}_3^-$  at 193 nm. (d)  $\text{SiAu}_3^-$  at 266 nm. (e)  $\text{SiAu}_4^-$  at 193 nm. (f)  $\text{SiAu}_4^-$  at 266 nm; the inset shows the spectrum of  $\text{SiAu}_4^-$  taken at 532 nm (2.331 eV).

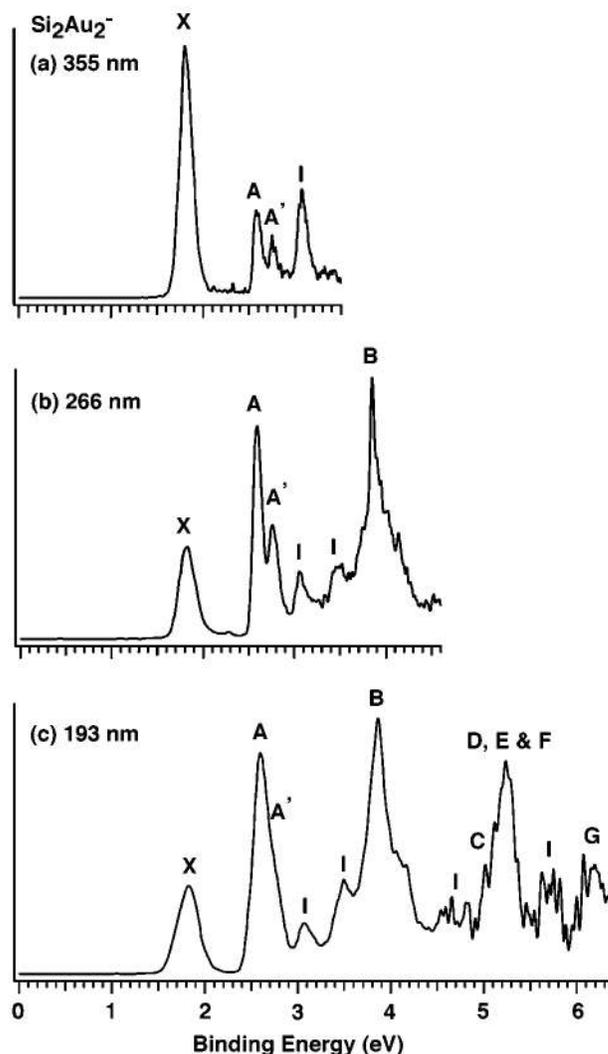


**Fig. 7** Optimized structures for the global minimum and low-lying isomers of  $\text{SiAu}_n^-$  and  $\text{SiAu}_n$ . All bond lengths are given in angstroms and angles in degrees. The relative energies (in bold) are in eV for the higher energy isomer. The values in the parentheses correspond to the neutral structures. See ref. 50 for computational details.



**Fig. 8** Comparison of the relevant frontier molecular orbitals between  $\text{SiH}_n$  and  $\text{SiAu}_n$  ( $n = 2-4$ ). (A) The LUMO ( $b_1$ ) of  $\text{SiH}_2$ . (B) The HOMO ( $a_1$ ) of  $\text{SiH}_2$ . (C) The LUMO ( $b_1$ ) of  $\text{SiAu}_2$ . (D) The HOMO ( $a_1$ ) of  $\text{SiAu}_2$ . (E) The HOMO ( $a_1$ ) of  $\text{SiH}_3$ . (F) The HOMO ( $a_1$ ) of  $\text{SiAu}_3$ . (G) The LUMO ( $a_1$ ) of  $\text{SiH}_4$ . (H) The LUMO ( $a_1$ ) of  $\text{SiAu}_4$ . (I) one of the three Si-H bonding orbitals of  $\text{SiH}_4$  ( $t_2$ ). (J) one of the three Si-Au bonding orbitals of  $\text{SiAu}_4$  ( $t_2$ ).

The total atomization energies, as well as the single Si-Au bond energies in  $\text{SiAu}_2$  (67.1 kcal/mol),  $\text{SiAu}_3$  (60.6 kcal/mol), and  $\text{SiAu}_4$  (62.7 kcal/mol), are quite high and they are



**Fig. 9** Photoelectron spectra of  $\text{Si}_2\text{Au}_2^-$  at (a) 355 nm, (b) 266 nm, and (c) 193 nm.

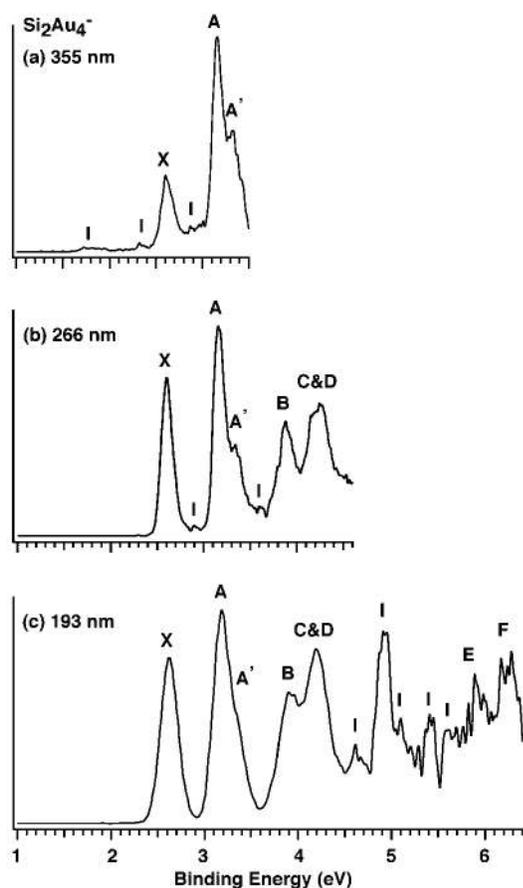
close to those in the corresponding Si–H molecules, SiH<sub>2</sub> (75.2 kcal/mol), SiH<sub>3</sub> (74.4 kcal/mol), and SiH<sub>4</sub> (79.6 kcal/mol).<sup>52</sup> These relatively high atomization energies and strong Si–Au bonds reflect both the covalent nature of the Si–Au bonds and the high stability of the SiAu<sub>*n*</sub> silicon auride molecules.

### 3.2 Si<sub>2</sub>Au<sub>*n*</sub><sup>−</sup> and Si<sub>2</sub>Au<sub>*n*</sub> (*n* = 2 and 4), and Si<sub>3</sub>Au<sub>3</sub><sup>+</sup>, Si<sub>3</sub>Au<sub>3</sub>, and Si<sub>3</sub>Au<sub>3</sub><sup>−</sup>

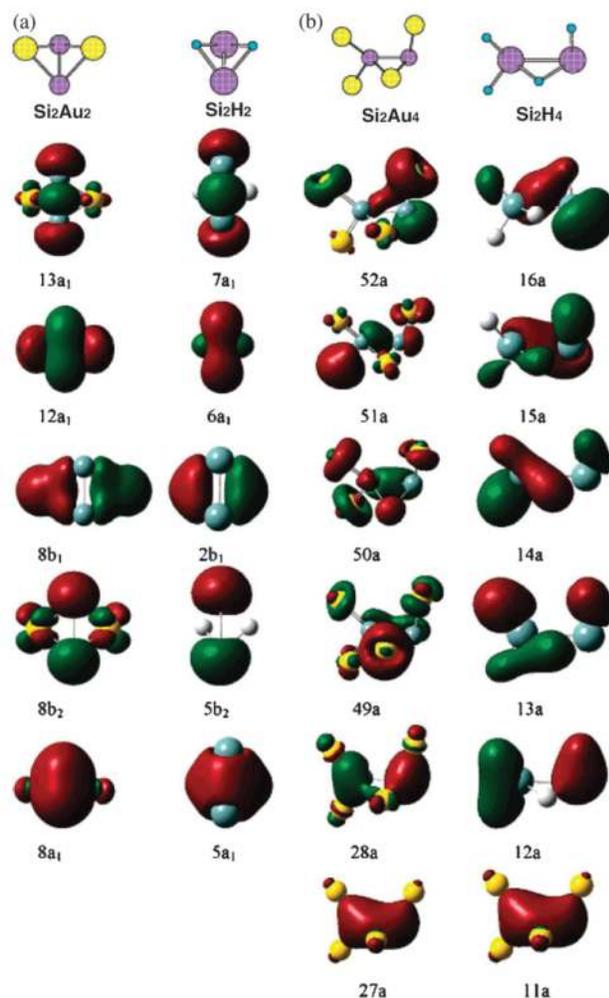
To test the generality of the Au–H analogy, several larger Si–Au binary clusters have been produced and investigated.<sup>53,54</sup> Fig. 9 and 10 display the PES spectra of Si<sub>2</sub>Au<sub>2</sub><sup>−</sup> and Si<sub>2</sub>Au<sub>4</sub><sup>−</sup> at various photon energies, which were used to compare with theoretical calculations to determine the most stable structures of Si<sub>2</sub>Au<sub>*n*</sub><sup>−</sup> and Si<sub>2</sub>Au<sub>*n*</sub> (*n* = 2 and 4).<sup>53</sup> It is well known that the acetylene and ethylene analogues of silicon do not possess the classical configurations. Instead, they prefer to form hydrogen-bridged or other distorted nonclassical structures.<sup>55–58</sup> We found that the di-silicon aurides also prefer nonclassical structures analogous to the corresponding hydrides. Similar to Si<sub>2</sub>H<sub>2</sub>, the most stable structure for Si<sub>2</sub>Au<sub>2</sub> has a dibridged configuration. For Si<sub>2</sub>Au<sub>4</sub>, the most stable isomer corresponds to a mono-bridged structure. More interestingly, we found that the potential energy surfaces of the di-silicon-gold systems are also very similar to those of the corresponding hydrides with similar

low-lying isomeric structures. In Fig. 11, the MOs of Si<sub>2</sub>Au<sub>2</sub> and Si<sub>2</sub>Au<sub>4</sub> are compared to their hydride counterparts. The similarity in both structure and bonding between the aurides and hydrides of the di-silicon systems are clearly shown.

We have also measured the PES of Si<sub>3</sub>Au<sub>3</sub><sup>−</sup> and investigated the Au–H analogy in the tri-silicon gold clusters.<sup>54</sup> PES and density functional calculations were combined to examine the geometric and electronic structure of Si<sub>3</sub>Au<sub>3</sub><sup>−</sup>. It was found that there are three isomers competing for the ground state of Si<sub>3</sub>Au<sub>3</sub><sup>−</sup>, as is the case for Si<sub>3</sub>H<sub>3</sub><sup>−</sup>.<sup>59</sup> Extensive structural searches showed that the potential energy surfaces of the tri-silicon gold clusters (Si<sub>3</sub>Au<sub>3</sub><sup>−</sup>, Si<sub>3</sub>Au<sub>3</sub>, and Si<sub>3</sub>Au<sub>3</sub><sup>+</sup>) are similar to those of the corresponding silicon hydrides. The lowest energy isomers for Si<sub>3</sub>Au<sub>3</sub><sup>−</sup> and Si<sub>3</sub>Au<sub>3</sub> are structurally similar with a Si<sub>3</sub>Au four-membered ring serving as a common structural motif. The Si<sub>3</sub>Au<sub>3</sub><sup>+</sup> cation is interesting because its hydride analog, the cyclotrisilylium ion (*D*<sub>3h</sub> Si<sub>3</sub>H<sub>3</sub><sup>+</sup>) is a 2π aromatic species, which has been extensively studied.<sup>60–64</sup> An aromatic cyclotrisilylium ion with bulky substituents,



**Fig. 10** Photoelectron spectra of Si<sub>2</sub>Au<sub>4</sub><sup>−</sup> at (a) 355 nm, (b) 266 nm, and (c) 193 nm.



**Fig. 11** (a) Comparisons of the five bonding molecular orbitals of the global minimum dibridged structure of Si<sub>2</sub>Au<sub>2</sub> with the corresponding structure and molecular orbitals of Si<sub>2</sub>H<sub>2</sub>. (b) Comparison of the six bonding molecular orbital pictures of the global minimum mono-bridged structure of Si<sub>2</sub>Au<sub>4</sub> and the corresponding structure and molecular orbitals of Si<sub>2</sub>H<sub>4</sub>.



Foils completed by  
Loma Linda University  
dental students under  
the guidance of Dr.  
Clyde Roggenkamp.



which bears similarities with  $\text{Si}_3\text{H}_3^+$ , has been successfully synthesized.<sup>65</sup> Our structural search indeed showed that the lowest energy isomer for  $\text{Si}_3\text{Au}_3^+$  ( $D_{3h}$ ,  $^1A_1$ ) is identical to  $\text{Si}_3\text{H}_3^+$ . A comparison of the valence MO's between the aromatic cyclotrisilylium ion  $\text{Si}_3\text{H}_3^+$  and the auride ion  $\text{Si}_3\text{Au}_3^+$  is shown in Fig. 12. As anticipated, there is a one-to-one correspondence in bonding between  $\text{Si}_3\text{Au}_3^+$  and  $\text{Si}_3\text{H}_3^+$ . The HOMO in both species is the  $\pi$  bond, which is responsible for their aromaticity. The remaining MO's are responsible for the Si–Au(H) and Si–Si  $\sigma$  bonding. Thus,  $\text{Si}_3\text{Au}_3^+$  is a  $2\pi$  aromatic molecule, analogous to the well established  $2\pi$  aromatic cyclotrisilylium ion  $\text{Si}_3\text{H}_3^+$  and extending the Au–H analogy to an aromatic Si–Au cluster.

Although Au and Si do not form stable alloys, the Au/Si interface has been studied extensively due to its importance in

microelectronics. It has been shown that despite the fact that Au is a very stable noble metal it is highly reactive on Si surfaces even at room temperature.<sup>66</sup> Several metastable Si–Au alloys, including a  $\text{SiAu}_4$  phase, have been observed to form in the Si–Au interface.<sup>67</sup> However, the nature of the chemical interactions between Au and Si in the Si–Au interface is still not well understood.<sup>68</sup> The finding of the Au–H analogy, the strong Si–Au covalent bonding, and the highly stable gaseous silicon auride species are consistent with the high reactivity of Au on Si surfaces and should provide further insight into the nature of the chemical interactions in the Si/Au interfaces.

### 3.3 The Au–H analogy in B–Au alloy clusters

Because of the similar electronegativity between B and Si, it was expected that Au may also act like H in B–Au alloy clusters. We have produced and obtained preliminary PES spectra for a wide range of  $\text{B}_x\text{Au}_y^-$  clusters. The first B–Au alloy cluster subjected to a detailed study was  $\text{B}_7\text{Au}_2^-$ ,<sup>69</sup> because its PES spectra were relatively simple with well-resolved vibrational structures in the ground state transition at 266 nm (Fig. 13), in contrast to the complicated spectra observed for pure  $\text{B}_7^-$ , which had contributions from three isomers.<sup>70</sup> We hypothesized that the  $\text{B}_7\text{Au}_2^-$  cluster would behave similarly as the  $\text{B}_7\text{H}_2^-$  system, which is a highly stable hydride cluster with a planar  $C_{2v}$  structure.<sup>71</sup> Theoretical calculations showed indeed that  $\text{B}_7\text{Au}_2^-$  possesses an extremely stable planar structure (Fig. 14), identical to that of  $\text{B}_7\text{H}_2^-$ , demonstrating that Au mimics H in its bonding to boron, analogous to the Au–Si bonding. As schematically shown in Fig. 14, the ground state structure of  $\text{B}_7\text{Au}_2^-$  ( $\text{B}_7\text{H}_2^-$ ) can be viewed as adding two Au (H) atoms to the

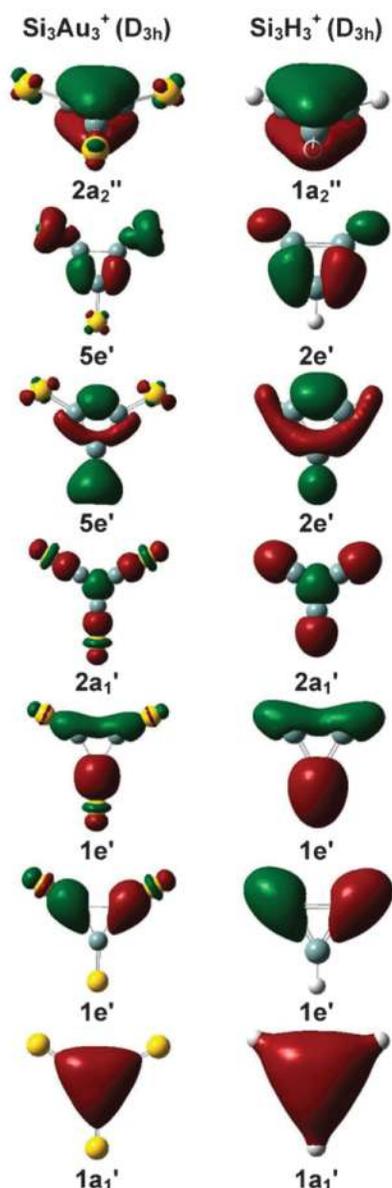


Fig. 12 Comparison of the valence molecular orbitals of  $\text{Si}_3\text{Au}_3^+$  and  $\text{Si}_3\text{H}_3^+$ .

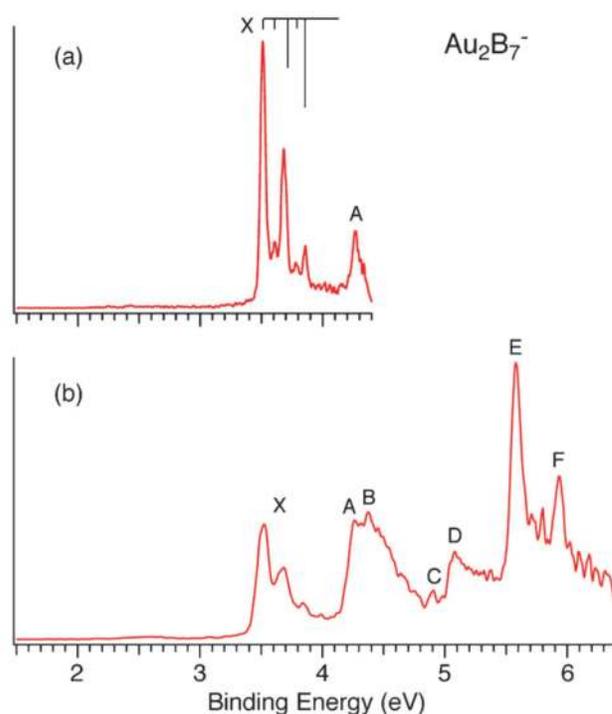
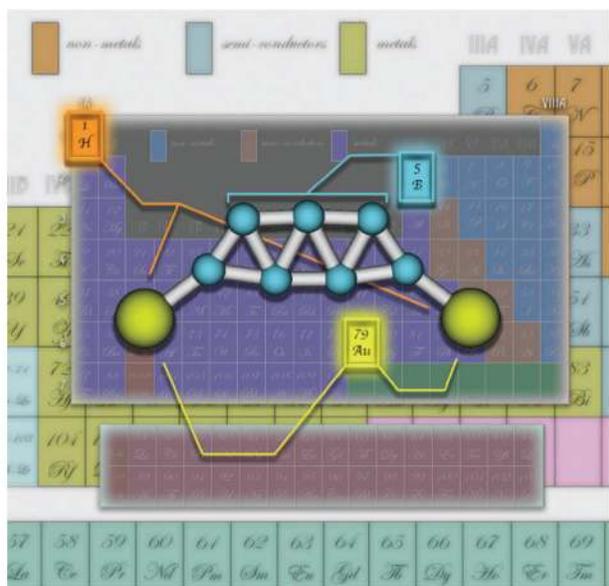


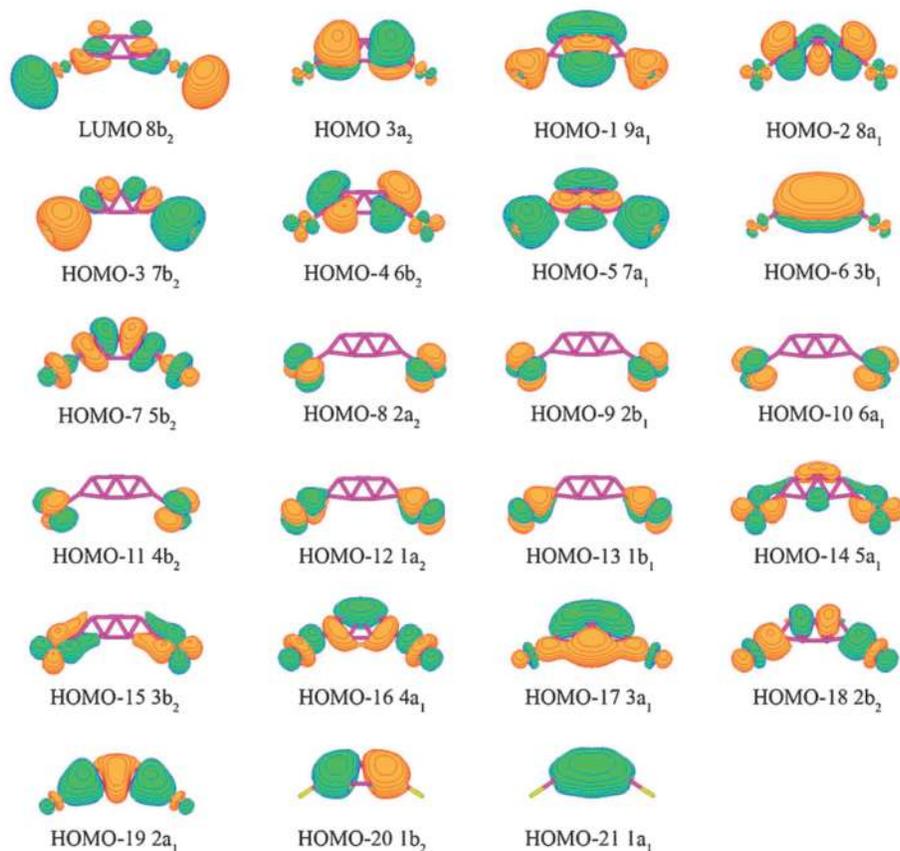
Fig. 13 Photoelectron spectra of  $\text{Au}_2\text{B}_7^-$  at (a) 266 nm and (b) 193 nm.



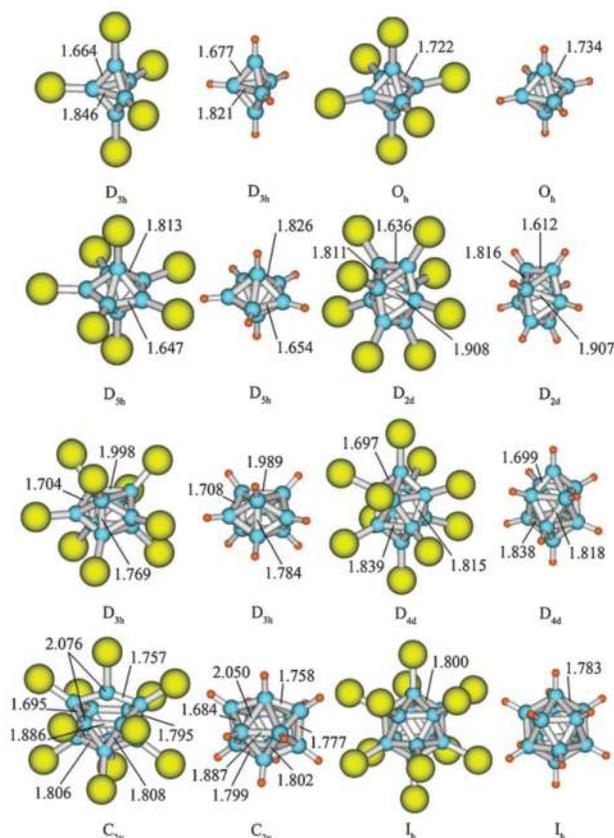
**Fig. 14** Schematics showing the global minimum structure of  $\text{Au}_2\text{B}_7$  and the Au-H analogy in  $\text{Au}_2\text{B}_7$  and  $\text{H}_2\text{B}_7$ .

terminal B atoms of an elongated planar isomer of  $\text{B}_7^-$ . Interestingly, this  $\text{C}_{2v}$  structure of  $\text{B}_7^-$  is a higher energy isomer<sup>70</sup> and it is significantly stabilized by the strong bonding with H and Au.

The bonding and stability in the planar  $\text{B}_7\text{Au}_2^-$  ( $\text{B}_7\text{H}_2^-$ ) cluster were understood on the basis of the strong covalent B-Au (H) bonding and the concepts of aromaticity and antiaromaticity.<sup>72-74</sup> The MO pictures of  $\text{B}_7\text{Au}_2^-$  are depicted in Fig. 15. Among the twenty two occupied valence MOs, ten are due to the Au 5d orbitals (HOMO-8 to HOMO-16 plus HOMO-18 (although a few of the lower-lying orbitals have significant mixing with the  $\text{B}_7$  backbone); seven are responsible for the formation of seven 2c-2e (two center two electron) peripheral B-B bonds (HOMO-2, HOMO-4, HOMO-7; HOMO-17, and HOMO-19 to HOMO-21); two are primarily responsible for the B-Au bonding (HOMO-3 and HOMO-5); and two are  $\pi$  orbitals (HOMO and HOMO-6). This leaves the HOMO-1 ( $9a_1$ ), which is a  $\sigma$ -orbital delocalized mainly over the five boron atoms that are not bonded to Au. Thus,  $\text{B}_7\text{Au}_2^-$  is  $\pi$ -antiaromatic ( $4\pi$  delocalized electrons) and  $\sigma$ -aromatic (2 delocalized  $\sigma$  electrons) with all other MOs representing the two 2c-2e B-Au bonds and the seven 2c-2e B-B peripheral bonds. The planar  $\text{B}_7\text{Au}_2^-$  structure can then be viewed as originating from the mixing of the Au 6s-5d hybrid orbitals with one of the delocalized  $\sigma$  orbitals in  $\text{B}_7^-$ , thus transforming the doubly antiaromatic  $\text{B}_7^-$  into a  $\sigma$ -aromatic but still  $\pi$ -antiaromatic  $\text{B}_7\text{Au}_2^-$  species. Essentially, a delocalized  $\sigma$  orbital, forming the original  $\sigma$ -antiaromatic pair of orbitals, is transformed to two B-Au localized bonds, gaining major stabilization for  $\text{B}_7\text{Au}_2^-$ . The elongated structure of the  $\text{C}_{2v}$   $\text{B}_7$  framework in  $\text{B}_7\text{Au}_2^-$  or  $\text{B}_7\text{H}_2^-$  is a result of the  $\pi$



**Fig. 15** Molecular orbital pictures of  $\text{Au}_2\text{B}_7^-$ .



**Fig. 16** Optimized geometric structures of  $B_xH_x^{2-}$  and  $B_xAu_x^{2-}$  ( $x = 5-12$ ) (see ref. 75) with selected B-B distances in Å. (Yellow—Au; Blue—B; Orange—H)

antiaromaticity. The stability of the  $C_{2v}$  planar structure of  $B_7Au_2^-$  is also reinforced by the two strong B–Au covalent bonds or B–H bonds in the case of  $B_7H_2^-$ .

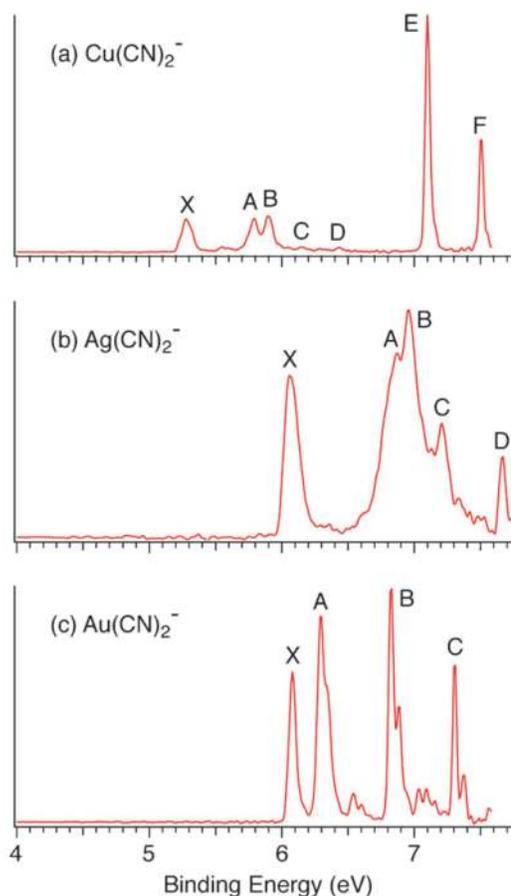
The similarity in stability, structure, and bonding in the global minima of  $B_7Au_2^-$  and  $B_7H_2^-$  is analogous to the Au–H analogy in Si–Au clusters. We found that the B–Au bonds in  $B_7Au_2^-$  are also highly covalent with very little charge transfer from Au to B, similar to the Si–Au bond. This finding inspired a computational investigation on the stability of closo-auro-boranes,  $B_xAu_x^{2-}$  ( $x = 5-12$ ),<sup>75</sup> which were found indeed to possess structures and bonding similar to the well-known deltahedral closo-borane cages,  $B_xH_x^{2-}$ , as shown in Fig. 16. The B–B bond lengths are similar between the auride and hydride boranes and the effective atomic charges on Au in  $B_xAu_x^{2-}$  are also very similar to those on H in  $B_xH_x^{2-}$ . The results suggest that the closo-auro-borane species are new chemical compounds that may be viable for chemical syntheses in the bulk. The Au atoms in the closo-auro-boranes represent highly atomically dispersed gold and may potentially exhibit novel catalytic and chemical properties.

### 3.4 Covalent bonding of Au in other mixed clusters

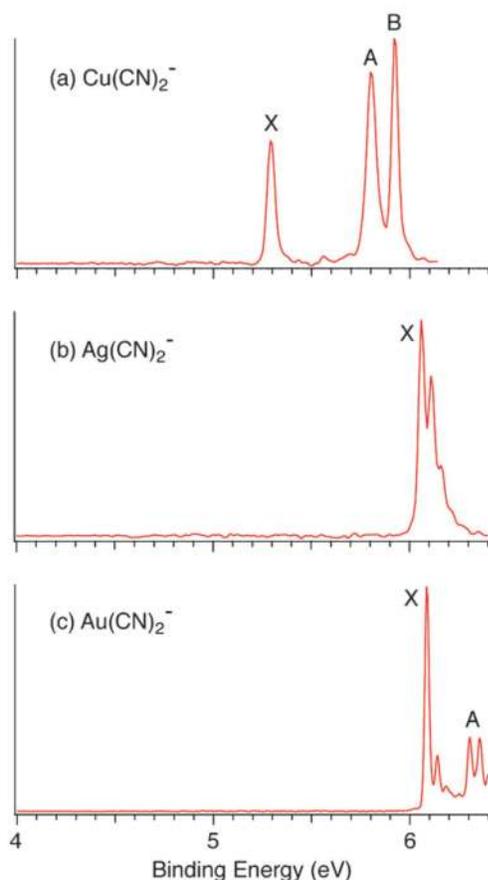
The Au–H analogy may be a more general phenomenon and may exist in many Au-containing molecules. In a study of the  $Au_2H^-$  hydride molecule,<sup>76</sup> it was found that the structure of this anion cluster is linear,  $[Au-Au-H]^-$ , whereas the neutral cluster is triangular. The structures of this simple gold hydride

are similar to the bare  $Au_3^-$  anion and its neutral, respectively. Thus, the H atom in the  $Au_2H^-$  hydride behaves like a Au atom!

During experiment on Au–B alloy clusters, an auro-boron oxide cluster  $Au_2BO^-$  was observed to be an intense peak dominating the Au–B mass spectra, along with weaker signals for  $AuBO^-$  and  $Au_3BO^-$ . PES and computational studies showed that  $Au_2BO^-$  is a closed shell molecule with a very high electron binding energy, whereas  $AuBO$  and  $Au_3BO$  neutrals are shown to be closed shell species with large HOMO–LUMO gaps, resulting in relatively low electron affinities.<sup>77</sup> The structures of  $Au_nBO^-$  ( $n = 1-3$ ) were compared with those of the corresponding  $H_nBO^-$  species in order to evaluate the analogy in bonding between gold and hydrogen in the new Au–BO clusters. It was found that the first gold atom does mimic hydrogen and interacts with the BO unit to produce a linear  $AuBO^-$  structure with significant Au–B covalent bonding. This unit preserves its identity when interacting with additional gold atoms: a linear  $Au[AuBO]$  complex is formed when adding one extra Au atom; two isomers are formed for  $Au_2[AuBO]$  with close energies. The  $Au_nBO^-$  species can be alternatively viewed as  $Au_n$  interacting with a  $BO^-$  unit,<sup>78</sup> which contains a highly stable  $B \equiv O$  triple bond and has been observed as building blocks in B-rich boron oxide clusters.<sup>79,80</sup> Since  $BO^-$  is isoelectronic to  $CO$ , the structures and chemical bonding in  $Au_nBO^-$  can also be



**Fig. 17** Photoelectron spectra of  $M(CN)_2^-$  ( $M = Cu, Ag, Au$ ) at (a) 157 nm (7.866 eV).



**Fig. 18** Photoelectron spectra of  $M(\text{CN})_2^-$  ( $M = \text{Cu}, \text{Ag}, \text{Au}$ ) at (a) 193 nm.

compared to those in the corresponding  $\text{Au}_n\text{CO}$  complexes, in which significant Au–CO bonding is observed.<sup>81,82</sup>

#### 4. Evidence of significant covalent bonding in $\text{Au}(\text{CN})_2^-$

The  $\text{Au}(\text{CN})_2^-$  ion is the most stable Au compound known for centuries, yet a detailed understanding about its chemical bonding as an isolated species was lacking until very recently.<sup>83</sup> Using electrospray and PES, we obtained direct experimental evidence of significant covalent characters in the Au–C bonds in  $\text{Au}(\text{CN})_2^-$  by comparison with its lighter congeners,  $\text{Ag}(\text{CN})_2^-$  and  $\text{Cu}(\text{CN})_2^-$ . Vibrational progressions in the Au–C stretching mode were observed in PES spectra for all detachment transitions for  $\text{Au}(\text{CN})_2^-$  in contrast to the atomic-like transitions for  $\text{Cu}(\text{CN})_2^-$ . DFT and high level *ab initio* calculations were carried out to understand the PES spectra and obtain insight into the nature of the chemical bonding in the  $M(\text{CN})_2^-$  complexes. Significant covalent characters in the Au–C bonding were shown in  $\text{Au}(\text{CN})_2^-$ , consistent with the experimental observations.

Fig. 17 presents the PES spectra of  $M(\text{CN})_2^-$  ( $M = \text{Cu}, \text{Ag}, \text{Au}$ ) at 157 nm. Surprisingly, there is very little similarity among the three spectra. The 157 nm spectrum of  $\text{Cu}(\text{CN})_2^-$  displays some weak signals in the lower binding energy range (X, A–D) and two sharp and intense atomic-like

transitions (E, F) in the higher binding energy range. The binding energies of  $\text{Ag}(\text{CN})_2^-$  and  $\text{Au}(\text{CN})_2^-$  are significantly increased relative to those of  $\text{Cu}(\text{CN})_2^-$ . The 157 nm spectrum of  $\text{Ag}(\text{CN})_2^-$  shows congested spectral features around 7 eV. Four well-resolved bands were observed for  $\text{Au}(\text{CN})_2^-$  (Fig. 17c), along with two weaker bands at around 6.5 and 7.1 eV due to multi-electron transitions.<sup>80</sup> Interestingly, vibrational progressions were observed in each PES band of  $\text{Au}(\text{CN})_2^-$ ; the X and A bands were better resolved at 193 nm, as shown in Fig. 18c. The measured vibrational frequencies were  $400\text{ cm}^{-1}$  for the X and A bands,  $480\text{ cm}^{-1}$  for the B band, and  $520\text{ cm}^{-1}$  for the C band. The vibrational features should correspond to Au–C stretching according to solution phase data<sup>84</sup> and our calculated vibrational frequencies. In contrast, the spectrum of  $\text{Cu}(\text{CN})_2^-$  was relatively sharp even at 193 nm (Fig. 18a) without any vibrational structure. The observed vibrational progressions in the PES transitions of  $\text{Au}(\text{CN})_2^-$  suggest significant bonding interactions between Au and C, providing direct experimental evidence for the covalency in the Au–C bonding.

High-level calculations were used to optimize structures, compute electron binding energies to aid spectral assignments, and analyze the chemical bonding in  $M(\text{CN})_2^-$  ( $M = \text{Cu}, \text{Ag}, \text{Au}$ ). The optimized geometries for  $M(\text{CN})_2^-$  and their respective neutrals are all linear. The computed Au–C bond length ( $1.99\text{ \AA}$ ) in  $\text{Au}(\text{CN})_2^-$  is significantly reduced relative to the Ag–C bond length ( $2.07\text{ \AA}$ ) in  $\text{Ag}(\text{CN})_2^-$  and is similar to the Au–C bond length in the monoligated  $\text{AuCN}$  ( $1.91\text{ \AA}$ ),<sup>85,86</sup> which has been suggested to possess multiple bonding characters.<sup>87</sup> The atomic-like PES transitions in  $\text{Cu}(\text{CN})_2^-$  are consistent with the ionic bonding nature in this system, whereas the bonding in  $\text{Ag}(\text{CN})_2^-$  should be in between.

The molecular orbital pictures for  $\text{Au}(\text{CN})_2^-$  are shown in Fig. 19. The HOMO and HOMO-8 describe strong Au–C  $\sigma$  bonding, whereas HOMO-6 is a strong  $\pi$  bonding orbital. The other valence MOs are either non-bonding or weakly bonding or antibonding. The chemical bonding in  $M(\text{CN})_2^-$  ( $M = \text{Cu}, \text{Ag}, \text{Au}$ ) was also investigated using population and bond order analyses, revealing clearly less positive charge on Au and a higher Au–C bond order in  $\text{Au}(\text{CN})_2^-$  than in  $\text{Cu}(\text{CN})_2^-$  and  $\text{Ag}(\text{CN})_2^-$ . Electron localization functions (ELF)<sup>88</sup> reflect the probability to find electron pairs, illustrating more vividly the increased covalency in the M–C bonding in  $M(\text{CN})_2^-$  from Cu to Au, as shown in Fig. 20. Fragment orbital analysis and orbital interaction analysis both reveal that the covalent character of Au–C and the remarkable stability of  $\text{Au}(\text{CN})_2^-$  stem from the strong relativistic effects of gold. The s-d hybridization significantly enhances the ability for Au to form covalent bonds with multiple bond characters. The covalent nature in the Au–C bonding gives the high stability of the  $\text{Au}(\text{CN})_2^-$  complex.

#### 5. Conclusions

Experimental and theoretical evidence has been obtained, showing that multiple bonding exists between Au and O or S in the Au mono- and di-oxide or sulfide molecules. The Au–CN bonding in the  $\text{Au}(\text{CN})_2^-$  complex has also been found to contain strong covalent characters. In a series of



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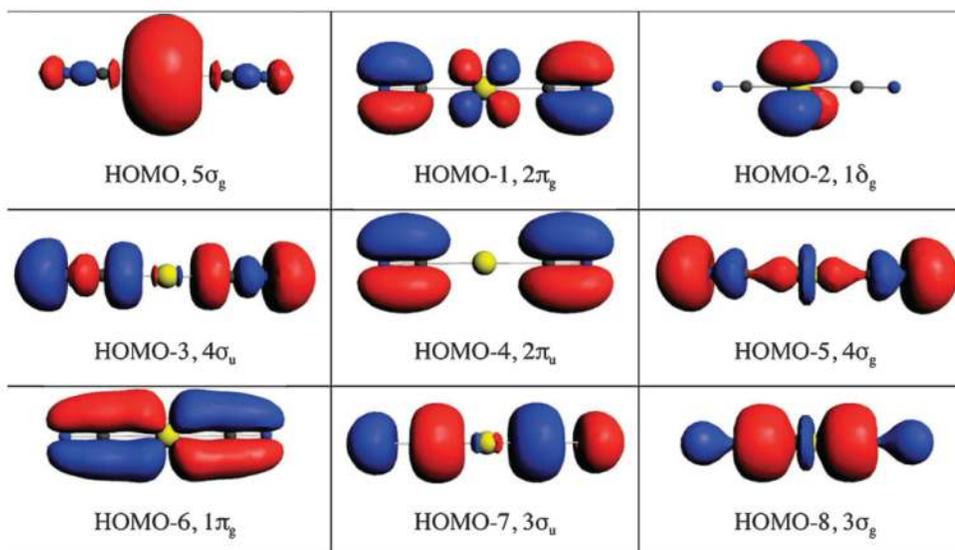


Fig. 19 Molecular orbital pictures of  $\text{Au}(\text{CN})_2^-$ .

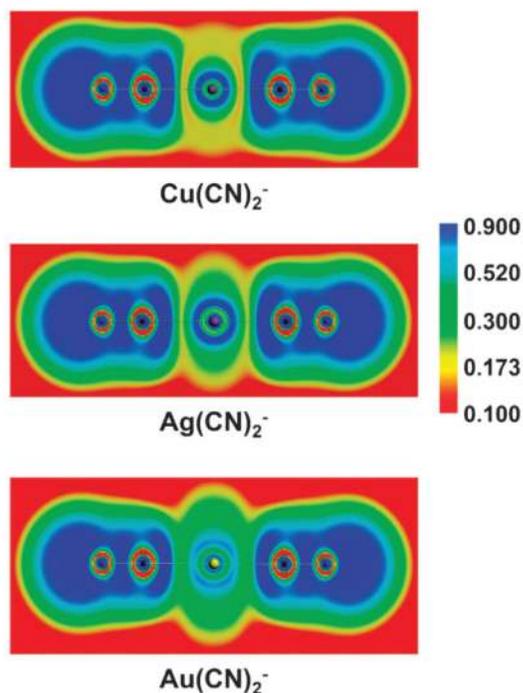


Fig. 20 Electron localization functions for  $\text{M}(\text{CN})_2^-$  ( $\text{M} = \text{Cu}, \text{Ag}, \text{Au}$ ).

binary Au clusters, it has been observed that Au behaves like H to form strong covalent bonds with Si or B analogous to the respective hydrides. The covalent bonding nature of gold is at the core of ligand-protected gold nanoparticles and homogeneous catalyses of organogold. It has been increasingly recognized that the Au–S covalent bonding dictates the interfacial structures and thus the chemical and optical properties of self-assembled monolayers and ligand-protected gold nanoparticles. Gold carbene complexes have also been found to contain covalent characters, which will contribute to a better understanding of homogeneous Au catalysis. Therefore, gold, which is known to be the noblest of all metals, has been

found to possess a wide range of interesting chemistry. It is conceivable that there are vast unknown chemistry and chemical compounds of Au yet to be discovered. Various multiply bonded species between Au and main group elements have been predicted and observed. Photoelectron spectroscopy in conjunction with computational chemistry is an ideal technique to probe these species and will further contribute to our understanding of the covalent nature of gold in many more compounds.

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2 <sup>nd</sup> Councilor	Dr. David Bridgeman	dfbdds@suddenlinkmail.com
3 <sup>rd</sup> Councilor	Dr. Richard Brinker	brinkerrlar@aol.com
Immediate Past President	Dr. Bruce Small	dr.bruce.small@gmail.com
Secretary	Dr. Marc Tollefson	marcdtollefson@msn.com
Treasurer	Dr. Barry Evans	barryoe@aol.com
Meeting Planner		
<b>Nominating Committee</b>		
Chair	Dr. Wendell Foltz	foltz@onlinenw.com
Member	Dr. Suzanne Grennell	stgrennell@me.com
Member	Dr. Bruce Small	dr.bruce.small@gmail.com
<b>Constitution and Bylaws Committee</b>		
Chair	Dr. Barry Evans	barryoe@aol.com
Member	Dr. David Thorburn	drdavidthorburn@gmail.com
Member	Dr. Mel Lund	melvin_lund@insightbb.com
<b>Scientific Sessions Committee</b>		
Chair	Dr. Robert Bridgeman	rhbridgeman@gmail.com
<b>Literature and Research Committee</b>		
Chair	Dr. Tim Carlson	tcarlson@iu.edu
<b>Education and Clinical Seminars Committee</b>		
Chair	Dr. David Thorburn	drdavidthorburn@gmail.com
Member	Dr. David Bridgeman	dfbdds@suddenlinkmail.com
Member	Dr. Bruce Small	dr.bruce.small@gmail.com
<b>AD-HOC COMMITTEES</b>		
<b>Inter-Academy Liaison Committee</b>		
Chair (President)	Dr. Alfred LaPorta	alpdds@alfredlaportadds.com
Member (President Elect)	Dr. Robert Bridgeman	rhbridgeman@gmail.com
Member (Secretary)	Dr. Marc Tollefson	marcdtollefson@msn.com
<b>Distinguished Member Award Committee</b>		
Chair	Dr. Tim Carlson	tcarlson@iu.edu
Member	Dr. Wendell Foltz	foltz@onlinenw.com
Member	Dr. Dan Henry	golddoc46@gmail.com
<b>Clinician of the Year Award Committee</b>		
Chair	Dr. Bruce Small	dr.bruce.small@gmail.com
Member	Dr. Tasha Bollerman	magosoul@gmail.com
Member	Dr. Alfred LaPorta	alpdds@alfredlaportadds.com
<b>Forward Looking Committee</b>		
Chair	Dr. Alfred LaPorta	alpdds@alfredlaportadds.com
<b>OTHER POSITIONS</b>		
<b>Gold Leaf</b>		
Editor	Dr. Dan Henry	golddoc46@gmail.com
<b>Website</b>		
Web Master	Dr. Scott Barrett	dr@bdental.net



# 2018 Minutes AAGFO Executive Council

October 24, 2018

Seattle, WA

Attending: Dr. Marc Tollefson, Dr. Scott Barrett, Dr. Tim Carlson, Dr. Warren Johnson, Dr. Bruce Small, Dr. Richard Tucker, Dr. Al La Porta, Dr. Clyde Roggenkamp, Dr. Dan Henry, Dr. Dave Thorburn, Dr. Robert Bridgeman, Dr. David Bridgeman, Dr. Barry Evans

**Call to Order:** 3:05 pm

Minutes from previous meeting were approved.

**President's Report: Dr. Bruce Small**

Dr. Bruce Small encouraged that our attendance has been consistent during the last 3 years.

Eighty percent of our dentists from India have failed to pay their dues and are no longer members. Only two remain.

**Secretary's Report: Dr. Marc Tollefson**

Sixteen dental schools received student achievement awards this year. This is consistent with the past few years. However many of the schools are no longer teaching direct gold.

Dr. Tollefson turned seventy this year and because of an illness was unable to work for the first three months of the year. He is now working half days but wants retire from his secretary duties. There was discussion on who might take over. Further discussion to follow.

**Treasurer's Report: Dr. Barry Evans:** We have 99 active members, and 6 new members with a net loss of 4 members. 10 have unpaid dues. We currently have a positive balance of \$5,000 this year and \$2,700 surplus for this meeting. There was a discussion on when dues need to be paid. Dr. Evans will make the final decision on this matter.

**By laws Report: Dr. Barry Evans**

Current bylaws state that to become an active member of the AAGFO you must successfully place a gold foil at the annual meeting. A motion was taken to change this foil requirement to placing a foil while being observed by a suitable mentor at a gold foil study club. A decision was made to table this matter for now.

**2018 Annual Meeting Report: Dr. Richard Tucker**

Some students will be working on dentoforms and are showing interest in gold foil technique. Dr. Tucker encouraged all of us to team up with them to help out. There will be fewer clinical operations this year due to interstate licensing requirements. We should break even for expenses.

**2019 Annual Meeting Report: Dr. Robbie Bridgeman**

This will be a joint AAGFO/ ARVT Study Clubs meeting- September 4-7 2019 at the Marriott Riverside Hotel in Morgantown, West Virginia. Those wishing to operate should contact Dr. Craig Bridgeman. We will be responsible for two 1 hour lectures. Dr. La Porta is incoming president. There was a suggestion to begin lectures to students in advance of the meeting to get them ready for



the meeting. There are 12 foil kits and 6 casting kits available for them to use. A letter will be sent to Dr. Borgia, the dean, confirming our upcoming meeting. It was noted that he was present at every function at our 2017 meeting.

### **Nominating Committee: Dr. Bruce Small**

The Executive council will be meeting to confirm 3 new councilors: Dr. Dave Thorburn, Dr. Dave Bridgeman, and Dr. Rick Brinker. We also will need a new councilor for next year.

### **Awards: 2018**

Clinician of the year: Dr. Al LaPorta. To be presented by Dr. Bruce Small

Distinguished member: Dr. Dan Henry. To be presented by Dr. David Thorburn

Special award: Dr. Rick Nash. To be presented by Dr. Richard Tucker

### **Old Business:**

Instruments: Dr. David Thorburn has received some new manufactured gold foil instruments from DenMat (Hartzell). He brought some with him and would like everyone to try them. Dr. Bruce Small requested Dr. Dave Thorburn, Dr. Robert Bridgeman, Dr. David Bridgeman and Dr. Al Laporta to form a committee and make some instrument order decisions such as how many, what type and their immediate demand.

We are still looking for a new Meeting Planner candidate.

### **New Business:**

Our 2020 annual meeting suggestions included: Indianapolis, Vancouver and Nebraska. This location is still to be determined.

Our 2021 Meeting suggestions were a joint ARVT study clubs/AAGFO meeting in Vancouver, or Germany. This is still to be determined.

Our new editor, Dr. Dan Henry would like gold foil pictures and interesting articles for the Gold Leaf.

Meeting adjourned at 5:44pm.

Prepared By: Dr. Marc Tollefson (Secretary)



M.W. #23 Cl VI Operator Dr. David Thorburn 12 years old

These are foils completed by our friend Dr David Thorburn of Vancouver, Canada. They are an outstanding representation of the work of a master operator. In addition, they show the long term positive outcomes for restorative dentistry that is healthy for the environment where it is placed, and demonstrates its effectiveness in preserving tooth structure over time.



J.L. #33 Cl V Operator Dr. D. Thorburn 21 years 9 months

#34 Cl V Operator Dr. D. Thorburn 20 years 9 months. Accidental contact with prophylactic paste.



T.M. #45 Cl I Operator Dr. David Thorburn 10 years 10 months

Attached is the poster presentation used at Friday's California Dental Association meeting by the platinized-gold study group of Loma Linda School of Dentistry.

Liudmyla Humen, Hung Nguyen, Kyle O'Connor, Clyde Roggenkamp

## Surface Hardness of Direct-placed Powdered Gold and Powdered Platinum Restorative Material

Liudmyla Humen, Hung Nguyen, Kyle O'Connor, Clyde Roggenkamp



### Introduction

Due to the ideal properties of gold, it is recommended for almost all restorations in dentistry except where esthetics might be of concern.<sup>1</sup> Platinum is generally known to increase the hardness properties of gold, and dental casting alloys can contain quantities of platinum up to 8 percent. Platinum is a cohesive metal that lightens the color of yellow gold-based alloys.<sup>2</sup> Platinum offers twice the hardness of gold, and is still used as an additive in some dental gold alloys.<sup>3</sup>

In 1937, classic investigations by Rule<sup>4,5</sup> concluded that platinum-centered gold foil exhibited increased hardness and wear resistance compared to pure 100% gold foil. Although Rule's study concluded that beneficial properties were proportional to the percent of platinum in the direct gold restorative material,<sup>4,5</sup> the actual gradation over a range of relative amounts was not tested.

Although gold and platinum metals are mutually cohesive and currently available in pure powdered form from precious metal refiners, their cohesive hardness in the condensed powdered form has not been tested incrementally.

The purpose of the present research was to quantify the hardness of gold by increasing percentages of platinum powder to foil-wrapped powdered gold pellets. This was to investigate if a predictable increase in hardness could be defined in terms of a factor or quotient, also if condensed powdered metal restoration surfaces were comparable in hardness to condensed foil.

### Methods and Materials

Specimens were prepared as follows and compared with an E-Z Gold control:

**E-Z Gold – 100% Au Powder** (0.3550 g Au powder + 0.3550 g wax = 0.7100 g)

**A – 100% Au Powder** (0.3550 g Au powder + 0.3550 g wax = 0.7100 g)

**B – 100% Au Foil** (regular gold foil = 0.3550 g, no wax)

**C – 10% Pt Powder** (0.0355 g Pt + 0.3195 g Au + 0.3550 g wax = 0.7100 g)

**D – 33% Pt Powder** (0.1185 g Pt + 0.2365 g Au + 0.3550 g wax = 0.7100 g)

**E – 15% Pt Foil** (assayed value) platinized foil = 0.3550 g, no wax)

Powdered gold and powdered platinum were added to melted pure dental beading wax according to individual sample specifications then kneaded by hand until homogeneous. Each cooled wax-metal dough sample was flattened to 2 mm thickness and cut into 1.8 mm diameter noodles. Noodles were cut into small 1.8 mm length pellets in a spiral-wire cutting cylinder. Specimen pellets were then wrapped in pure gold foil squares (cut from 4-inch square foils with 4 mil thickness). Test cavities approximately 4 mm by 2 mm (1.2 mm deep) were prepared in extracted teeth with #330 carbide bur. All wax was incinerated from each pellet over a controlled flame. All specimens were condensed with a McShirley Electromallet at constant intensity/frequency by a single operator.



The specimens were smoothed with 600 grit wet abrasive paper before polishing with 0.03 micron aluminum oxide particles and Amalgloss powder. Each specimen was stored in de-ionized water at 37°C for 7 days until testing with a Leco Hardness Tester. Knoop Hardness Numbers (KHN) were recorded from the average of 30 micro indentations per specimen.

### Results

The E-Z gold control group (100% powdered Au) showed KHN values similar to Group B (100% Au foil) indicating consistent experimental technique and data collection (see Table 1). Group D (33% powdered Pt) was comparable to Group E (15% Pt foil, assayed). A proportional increase in KHN was noted from Group A (100% powdered gold) to Group C (10% Pt powder). There was further proportional hardness noted in Group D (33% Pt powder). This basically demonstrated that except for 15% platinized foil, not only powdered forms of gold and platinum are equivalent in hardness to foil forms but 33.3% platinum content can be expected to impart about 40% additional hardness in the restoration. An overall decrease in standard error with the increase in powdered platinum content indicated an increase in homogeneity of the mixture.

Table 1. Average hardness readings in Knoop Hardness Numbers (KHN) for each specimen.

Specimen	Average Hardness (KHN)	Standard Error
E-Z Gold (control)	83.8	19.4
Group A	87.7	9.2
Group B	83.4	11.1
Group C	93.7	10.5
Group D	122.0	16.7
Group E	121.9	10.2

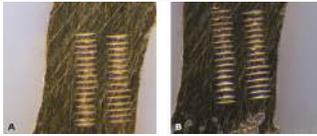


Figure 1. Photomicrographs showing the microhardness indentation marks in pure gold (A) and platinized gold (B) specimens. Note difference in color tone in the restoration when platinum is added to gold.

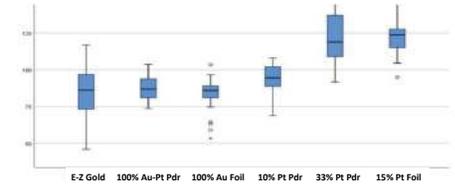


Chart 1. Average KHN in all group specimens.

### Discussion

Platinum can be added to gold due to the malleable and cohesive properties of both metals, not only to themselves, but also to each other. Both metals provide durable direct chairside dental restorations. Platinized gold adds wear hardness beyond ordinary gold foil restorations.<sup>3</sup> The 33.3% platinum powder sample (Group D) increased hardness by 39.1% compared to the 100% gold powder sample (Group A). This is reasonably close to a literature-extrapolated value of 1.02-1.15% for increased hardness per percentage platinum added.<sup>4,5</sup> The pattern of increased hardness with addition of platinum seen in Chart 1 would support the validity of using a powdered form of both platinum and gold for direct fillings. Although additional durability is desirable, a point may be reached where increasing platinum content interferes with satisfactory condensability of the restoration. Besides the traditional 15% platinized foil (by actual Almanon Inc. assay, April 2019) other more effective concentrations of gold may provide even greater wear resistance with relative ease of condensation. Future related studies would involve more specimens per group for greater validity of results. Of additional interest is to compare wear resistance of platinized to non-platinized gold using the wear-testing machine and surface polish resistance to toothbrush wear-testing, to investigate extent of Pt addition before condensability might become impractically manageable, and to clarify why 15% Pt foil in this study gave KHN values equivalent to that expected for 33%.

### Conclusions

Hardness of condensed 100% gold powder is comparable to condensed 100% gold foil. Pure gold hardness rises approximately 1% for each 1% addition of platinum and anticipated hardness can be estimated.

### References

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- Hisatsune K, Shiraishi T, Takuma Y, et al. Two different types of age-hardening behaviors in commercial dental gold alloys. J Mater Sci 2007; 18:577-581.
- Rule R.W. A further report on physical properties and clinical values of platinum-centered gold foil as compared to pure gold filling materials. J.A.D.A. & D. Cos 1937; 24:583-595.
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# AMERICAN ACADEMY OF GOLD FOIL OPERATORS

## CONSTITUTION AND BYLAWS

REVISED 2002, 2005, 2007, 2008, 2009, 2010, 2011, 2012, 2015

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#### CONSTITUTION

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### AMERICAN ACADEMY OF GOLD FOIL OPERATORS

#### CONSTITUTION

##### ARTICLE I

###### NAME

Section 1 The name of this organization shall be the AMERICAN ACADEMY OF GOLD FOIL OPERATORS, hereinafter referred to as “the Academy” or “this Academy.”

##### ARTICLE II

###### OBJECTIVES

Section 1 The objectives of this Academy are to:

- a. Promote the preservation of natural teeth, through quality dental treatment.
- b. Encourage, by practice and teaching, the treatment of carious lesions with direct filling gold and/or partial coverage cast gold.
- c. Encourage and demonstrate treatment under the most ideal and aseptic conditions known to restorative dentistry by application and use of the rubber dam.
- d. Encourage education and research in the aforementioned areas.

##### ARTICLE III

###### ORGANIZATION

Section 1 This Academy is an incorporated, not-for-profit organization. The Academy was begun in 1952, and shall continue until terminated by a two-thirds (2/3) majority vote of eligible members present at an annual or a special meeting.

Section 2 The Academy shall operate exclusively as a business league with Scientific and Educational organization within the meaning of Section 501 (C) (6) of the Internal Revenue Code of 1954 and it may engage in any and all lawful activities incidental to its needs and purposes, except as restricted herein.

Section 3 The office of the Academy shall be located in a place determined by the Executive Council of the Academy, consistent with the location of the Secretary.



Section 4 If this Academy is dissolved at any time, no part of its funds or property shall be distributed to, or among its members, but after the payment of all indebtedness of the organization, the remaining funds and properties shall be used to foster the advancement of operative dentistry in a manner to be determined by the Executive Council of the Academy.

Section 5 The membership of the Academy shall consist of qualified individuals as described in Chapter 1 of the Bylaws. In the event of the death or resignation of a Member, or his forfeiture of or expulsion from membership, neither he, his estate, or legal representative shall have any right, title or interest in any real or personal property of the Academy.

## ARTICLE IV GOVERNMENT

Section 1 The legislative body of the Academy shall be the Active and Life members, assembled in an annual meeting or a special meeting of the Academy.

Section 2 The Administrative body of the Academy shall be the Executive Council, as provided in Chapter IV of the Bylaws.

## ARTICLE V OFFICERS

Section 1 The elective officers of this Academy shall be the Immediate Past President, President, President-elect, Vice-president, Secretary, Treasurer and three councilors, and the Meeting Planner, who shall be elected by the legislative body at the annual meeting of the Academy.

## ARTICLE VI MEETINGS

Section 1 There shall be an annual meeting of the Academy at a location and time determined by the Executive Council, and the members notified thereof.

Section 2 A special meeting of the Academy may be called by the President or Executive Council at any time. At the request of 10% of the Active members in good standing, the President shall call a special meeting.

## ARTICLE VII AMENDMENTS

Section 1 This constitution may be repealed, altered or amended at any annual meeting by a two-thirds (2/3) vote of the Legislative body present and voting, provided that notice of such proposed amendment shall have been submitted in writing or via electronic communication to the members entitled to vote, at least thirty (30) days prior to the date of the meeting at which the amendment is to be presented.

## BYLAWS

- Chapter I Membership
- Chapter II Dues, Admission Fee and Fiscal Year
- Chapter III Officers
- Chapter IV Executive Council
- Chapter V Election of Officers and Councilors
- Chapter VI Committees
- Chapter VII The Journal
- Chapter VIII Meetings
- Chapter IX Principles of Ethics
- Chapter X Procedure at Meetings
- Chapter XI Amendments



AMERICAN ACADEMY OF GOLD FOIL OPERATORS  
BYLAWS

CHAPTER I  
MEMBERSHIP

Section 1 Classification

The members of the Academy shall be classified as follows:

- a. Active
- b. Associate
- c. Life
- d. Honorary
- e. Student

Section 2 Qualifications for Membership.

a. Active Member. An Active member must be an ethical dentist who is active in the practice of dentistry, a member of a dental school faculty, or an officer on active duty in the service of his country.

1. An Active member shall have been an Associate member in good standing of this Academy for at least twelve months, and must have operated successfully at an annual meeting of the Academy.

b. Associate Member. This represents the initial membership designation for all who enter the Academy. The professional background and ethical concerns are identical to those mentioned for Active Members.

c. Life Member. Any member who has maintained uninterrupted membership in the Academy for ten years or more and is completely retired from dental practice and/or teaching in a dental school.

d. Honorary Member. A person who has made outstanding contributions to operative dentistry or has rendered important service to the profession or this Academy, shall be considered for Honorary membership.

e. Student Member. A student at an accredited dental school may apply for & receive a student membership in the academy provided he or she is sponsored by a current active or life member of the academy. After Graduation from Dental School the Student member will automatically become an Associate Member.

Section 3 Election of Members.

a. Active Member.

1. Once He/She has been an associate member for at least twelve months and having successfully demonstrated a clinical presentation at an annual meeting of the Academy, the Associate member shall be approved by the Executive Council as an Active Member. Associate Members approved by the Executive Council shall be voted on at the next annual meeting of the Academy. A majority of the votes cast is required to elect an applicant to Active membership.

b. Associate Member.

1. For Associate membership, the method of application shall be on the approved form, accompanied by the appropriate fee and forwarded to the Secretary or Treasurer.

c. Life Member.

1. Life membership shall be granted by the Executive Council upon recommendation by the Treasurer or other Executive Council Member after they have verified the applicant's qualifications for Life Membership.

d. Honorary Member.

1. Nominations for Honorary membership status shall be submitted in writing to the Secretary, and signed by three Active members in good standing. The application shall be presented to the Executive Council for approval. After

approval by the Executive Council, the nomination shall be presented to the Legislative Body for approval by a majority of those voting.



Section 4 Rights and Privileges.

a. Active and Life Members.

1. Active and Life members in good standing and Honorary members shall have all the rights and privileges of the Academy.

b. Other Members.

1. Associate members in good standing, and Student members shall have all the rights and privileges of the Academy, except to make nominations, and to hold office.

Section 5 Certificates of Membership.

a. The Secretary shall provide for the issuance of certificates evidencing membership in the Academy, in such form as may be determined by the Executive Council. Such certificates shall be signed by the President and by the Secretary.

Section 6 Status of Membership.

a. Good Standing.

1. A member remains a member until he has resigned or until forfeiture of his membership has been declared by the Executive Council. A member is "in good standing" when his dues are not delinquent and his assessments are paid up to and including the current year.

b. Resignation.

1. Any member in good standing may resign by filing written or oral notice thereof with the Secretary or Treasurer.

c. Forfeiture of Membership.

1. Membership in the Academy shall be forfeited:

a. For non-payment of dues within the required time period (see Section 5 of Chapter II). Membership in the Academy shall be forfeited after reasonable attempts have been made to collect delinquent dues by the Academy Treasurer.

b. For malpractice or gross misconduct.

2. The Executive Council shall declare the forfeiture of membership after the forfeiture has occurred. Such declaration shall not be made until the member has been informed of the tentative judgment of the Executive Council and given ample opportunity to present evidence showing that forfeiture was not warranted.

d. Reinstatement to Membership.

1. If membership has been forfeited for non-payment of dues, the member may be automatically reinstated by paying all delinquent dues or be advised to apply as a new applicant.

## CHAPTER II

### DUES, ADMISSION FEE AND FISCAL YEAR

Section 1 The fiscal year for this Academy shall be January 1 to December 31, inclusive.

Section 2 The period of annual membership shall coincide with the fiscal year.



Section 3 An application fee, to be determined by the Executive Council, shall be submitted to the Secretary with an application form for Associate membership. (No additional fee shall be required of an Associate member for transfer to Active status).

Section 4 Annual Dues and Assessments.

- a. The annual dues of the Academy shall be set by a majority vote of the Active and Life members at the annual meeting, acting upon recommendations of the Executive Council.
- b. Dues shall include a subscription to the Journal of Operative Dentistry. Those members who are also members of the Academy of Operative Dentistry or the Academy of RV Tucker Study Clubs will receive a refund in the amount of the subscription upon payment of dues to all three organizations when requested in writing from the Journal of Operative Dentistry office.
- c. Dues shall be paid in U.S. currency with check written on a U.S. bank, or a money order in U.S. funds, or credit card.
- d. Life and Honorary and Student members shall be exempt from the payment of annual dues.
- e. The first payment of annual dues shall be required January 1 of the year following the election of an individual to membership.
- f. Such periodic assessments as may be deemed necessary to meet expenses may be levied on the membership when determined by the Executive Council and passed by a majority vote at an annual meeting of the Academy.

Section 5 Delinquency of Dues.

- a. Dues shall become due and payable on January 1 of each year and shall become delinquent if not paid by March 31. A late charge, determined by the Executive Council, will be assessed a delinquent member.
- b. The Executive Council may extend the time for the payment of dues when a member is temporarily unable to pay because of extenuating circumstances.

CHAPTER III

OFFICERS

Section 1 Elective Officers.

- a. The elective officers of the Academy shall be the Immediate Past President, President, President-elect, Vice-president and Secretary, Treasurer and three councilors and the Meeting Planner.

Section 2 Duties.

- a. Immediate Past President. The Immediate Past President Shall:
  - 1. Be an advisor to the President and Executive Council.
  - 2. Attend all Executive Council meetings.
  - 3. Serve as Vice – Chairman at Executive Council meetings.

b. President. The President shall:

- 1. Preside at all meetings of the Academy.
- 2. Be an ex officio member of all committees.
- 3. In the event that the office of any officer or any member of the Executive Council becomes vacant before expiration of the elected term, appoint a successor for the unexpired term, subject to approval by the Executive Council.
- 4. Appoint members and name the chairs of all standing committees.
- 5. Perform such other duties as usually appertain to the office.

c. President-elect. The President-elect shall:

- 1. Be an assistant to the President.
- 2. Be Chair of the Scientific Sessions Committee for the current year.



3. Assume the duties of the President in the absence or disability of the President, and shall succeed to that office in the case of vacancy.

4. Assume the office of President at the installation of officers the next year.

d. Vice-president. The Vice-president shall:

1. Be an assistant to the President.
2. Be responsible for the arranging and coordination of the clinical portion of the program for the annual meeting.

e. Secretary- The Secretary shall:

1. Attend and keep records of all meetings of the Academy and the Executive Council.
2. Distribute to the membership the slate of the Nominating Committee, names of all applicants for membership, and any proposed changes in the Constitution and Bylaws at least thirty (30) days prior to the annual meeting.
3. Notify the members of meetings, of election to office, of appointments to committees and similar matters.
4. Notify applicants and nominees to membership of the status of their application or nomination.
5. Maintain a roster of members,
6. Have charge of all correspondence of the Academy.
7. Keep in safe custody the Seal of the Academy, affix the same to any instrument or document requiring it, and when so affixed, it shall be attested by Secretary's signature or by the signature of an officer duly authorized by the Executive Council.
8. Act as coordinator of all committees to ensure that they are functioning effectively, be responsible for the collection of all committee reports, maintain a file of such reports, and collect all committee records when the term and function of each committee is concluded.
9. Transfer the active file of each committee to its successor.
10. Perform such other duties as usually appertain to the office of Secretary and such other duties as may be required by the.

f. Treasurer The Treasurer shall:

1. Attend all meetings of the Academy and the Executive Council.
2. Maintain all financial records of the Academy.
3. Send out dues statements to all members of the Academy.
4. Collect and record dues payments from Academy Members.
5. He or she shall notify the Executive Council of members who are delinquent in dues.
6. Have custody of all funds of the Academy and keep proper record of all receipts and disbursements.
7. Present a report of the financial affairs of the Academy to the Executive Council, and the membership at each annual meeting of the Academy, and at such other times as the may require.
8. Be responsible to the Executive Council for an annual review of the fiscal affairs of the Academy, in addition to the usual financial report.
9. Perform such other duties as usually appertain to the office of Treasurer.
10. Turn over promptly to a successor all funds, securities and properties in his/her possession of whatever nature that belong to the Academy.

g. Meeting Planner: The Meeting Planner shall:

1. Attend all Executive Council meetings.
2. Arrange contracts for hotel and operating facilities for future Academy Annual meetings.
3. Send out announcements for upcoming annual meetings.
4. Collect Annual meeting registration fees.
5. Pay Annual meeting expenses.

### Section 3 Compensation to officers.

a. Compensation to the President. The Academy shall compensate the President for reasonable expenses incurred in attending the annual and interim meetings, as determined by the Executive Council.



b. Compensation to the Secretary & Treasurer. The policy regarding compensation to the Secretary-Treasurer for expenses incurred in attending recognized Academy meetings shall be determined by action of the Executive Council.

## CHAPTER IV

# EXECUTIVE COUNCIL

### Section 1 Composition

a. The Executive Council shall consist of the President, Immediate Past President, President-elect, Vice-president, Secretary, Treasurer and three Councilors, consisting of three additional Active members, one of whom shall be elected annually to serve for three years, and the Meeting Planner.

b. The President shall be the Chair, the Immediate Past President shall be the Vice-chair, and the Secretary shall be the Secretary of the Executive Council.

c. The Executive Council shall have full power to act in behalf of the Academy in the interval between meetings of the Academy.

### Section 2 Executive Council Meetings.

a. The Executive Council shall meet twice annually - once at a time approximating the date of the annual meeting of the Academy.

b. The Executive Council may also meet at the call of the Chair and two other members of the Executive Council, or on written notice to the Chair by at least four members of the Executive Council.

c. The Secretary shall give written notice of the time and place of the meeting of the Executive Council to all members at least thirty (30) days before the meeting.

d. At any meeting of the Executive Council, duly called, four members shall constitute a quorum, provided that at least two of the following officers be present: the Chair, the Vice-chair and the Secretary.

e. Any member of the Academy may attend the meetings of the Executive Council. A member may take part in its proceedings when invited to do so by the Chair, but is not entitled to vote.

### Section 3 Powers The Executive Council shall be the administrative body of the Academy, vested with full power.

a. It shall have the power to establish rules and regulations consistent with these Bylaws in governance of the Academy.

b. It shall have the power to establish dues for all classes of members, subject to review and approval of the voting members at the Annual Meeting.

c. It shall have the power to disburse the funds of the Academy.

### Section 4 Duties It shall be the duty of the Executive Council to:

a. Provide for the maintenance of all records and property of the Academy.

b. Determine the time and place for the Annual Meeting and for special meetings of the Academy.

c. Provide a suitable program for each Annual Meeting.

d. Report all of its actions and proposals to the membership.

e. Provide an accounting of changes in membership in the Academy.

f. Present to the membership at each Annual Meeting nominations for office in the Academy.

g. Perform such other duties as prescribed by these Bylaws.

## CHAPTER V

# ELECTION OF OFFICERS AND DIRECTORS

### Section 1 Election of officers

a. Elections shall be held each year at the general business session of the annual meeting of the Academy, at which time there shall be elected an Immediate Past President, President, President-elect, a Vice-President, each to serve one year, Secretary and Treasurer, each to serve three years, or until such successors are elected, and a Councilor to serve for three years and a Meeting Planner, who will serve for three years or until a successor has been elected. All officers of the Academy are elected annually.



b. Vacancies of Office. In the event the office of President becomes vacant, the President-elect shall become President for the unexpired term. The President-elect will continue to perform the duties of that office as well as the office of President. The President-elect will then continue as President for the normal rotation of office. In the event the office of Vice-president becomes vacant, the ranking member of the Executive Council will assume that office. The Nominations Committee will fill vacancies in the position of Councilor.

Section 2 Nominations for elective offices

- a. Nominations shall be made by the Nominating Committee and submitted to the Secretary at the midwinter meeting of the Executive Council.
- b. The slate of the Nominating Committee shall be sent to the entire membership at least thirty (30) days prior to the annual meeting by the Secretary.
- c. Nominations may also be made by an Active member provided such nominations are made in writing, endorsed by three other Active members, and received by the Secretary at least one week in advance of the election proceedings.

Section 3 Election of officers

- a. Election shall be by written ballot if requested by any single member present and entitled to vote. Otherwise it may be by acclamation.
- b. The candidate receiving the majority of votes shall be declared elected. If there are over two nominees, and if no one of them receives a majority, the two nominees receiving the highest vote shall be voted upon.

Section 4 Installation of officers

- a. An appropriate ceremony, determined by the Executive Council, shall install the newly elected officers.

Section 5 Assumption of Office

- a. The Executive Council shall assume office at the termination of the annual meeting and all records shall be turned over to the Secretary or Treasurer within thirty (30) days if this position has changed hands.

CHAPTER VI

COMMITTEES

Section 1 The Standing Committees of the Academy shall include the following: Scientific Sessions, Education and Clinical Seminars, Literature and Research, Nominating, Finance and Constitution and Bylaws.

Section 2 Committees

a. Scientific Sessions Committee.

- 1. The President-elect shall be the Chair of the Scientific Sessions Committee, assisted by the Vice-president, Meeting Planner, and others as deemed necessary.
- 2. This Committee shall plan and arrange all phases of the annual program and meeting, with approval of the Executive Council.

b. Education and Clinical Seminars Committee.

- 1. The Education and Clinical Seminars Committee shall consist of a Chair and at least five other members, appointed by the President, one-third ( 1/3) of which shall be appointed annually.
- 2. This Committee shall promote the use of rubber dam to the members of the dental profession and to dental schools.
- 3. This Committee shall promote and assist in the formation of cast and direct gold clinical seminars. It should review and continue to improve informational material currently available through the Academy for this purpose.
- 4. Upon requests from schools for means of improving the technical ability of students in operative dentistry, this Committee shall work in conjunction with the President and Secretary of the Academy to arrange for qualified individuals to assist in this endeavor.
- 5. This Committee shall maintain a current list of all active clinical seminar groups.

c. Literature and Research Committee.

- 1. The Literature and Research Committee shall consist of a Chair and five other members, appointed by the



President, one-third (1/3) of which shall be appointed annually.

2. This Committee shall encourage members of our profession, as well as research institutes of the armed forces, government, dental schools, and private enterprise to conduct research on direct filling gold, rubber dam, and cast gold restorations.

3. This Committee shall also review the literature for articles on cast and direct filling golds and rubber dam which could be brought to the attention of the Editor of the Academy's official journal.

#### d. Nominating Committee.

1. The Nominating Committee shall consist of the three most immediate past presidents. The senior member shall serve as Chair. It shall nominate candidates for elective offices, and shall furnish the Secretary with its recommended slate at the midwinter meeting of the Executive Council.

#### e. Constitution and Bylaws Committee.

1. The Constitution and Bylaws Committee shall consist of a Chair and at least two other members, appointed by the President.

2. The duty of this committee will be to ensure that the Constitution and Bylaws of this Academy are maintained in a timely and orderly fashion, and will present suggested changes to the Executive Council in order to allow the membership to have at least 30 days' notice prior to voting on any additions/deletions at the next annual meeting.

### Section 3 Other Committees

a. Other committees may be appointed as necessary by the President, subject to approval by the Executive Council, based upon existing requirements of the Academy.

b. A majority of the members of any committee shall constitute a quorum for the transaction of business.

c. The Chair of each committee shall submit a written report to the Secretary in sufficient time for consideration by the Executive Council, prior to the annual meeting. A copy of the report shall be filed in the committee's permanent folder.

d. In the event a member of any committee is unable to continue in service, through any legitimate reason, the President, with the approval of the Executive Council, shall be empowered to appoint a successor for the unexpired term.

## CHAPTER VII

### THE JOURNAL

#### Section 1 Name.

a. This Academy shall join with the Academy of Operative Dentistry and the Academy of R.V. Tucker Study Clubs to publish, or cause to be published, a journal under the title OPERATIVE DENTISTRY.

#### Section 2 Ownership.

a. This Journal shall be organized as a non-profit corporation. The membership of this corporation shall be divided equally from the members of the governing boards of the American Academy of Gold Foil Operators, the Academy of Operative Dentistry and the Academy of R.V. Tucker Study Clubs. This corporation is separate from the non-profit corporations of the *three* Academies. The stock ownership of this Journal shall be divided equally between the three Academies

#### Section 3 Management.

a. The Journal shall be managed by a Board of Directors consisting of the Editor, the Managing Editor, two representatives from the Academy of Operative Dentistry, two representatives from this Academy and two members from



the Academy of R.V. Tucker Study Clubs.

b. The two representatives from this Academy shall be the President and Secretary, or designated alternates of either.

## CHAPTER VIII

### MEETINGS

#### Section 1 Annual Meeting.

a. There shall be an annual meeting of the Academy for the election of officers, the transaction of business, the reading of papers upon professional subjects, the presentation of clinics, and for such other purposes as may be determined by the Executive Council.

b. The Executive Council shall determine the time and location of the Annual Meeting.

#### Section 2 Special Meetings.

a. Written notice of any special meeting of the Academy shall be sent to members at least two months in advance of the meeting. The notice shall specify the time and place of the meeting and the items of business to be conducted. No other business may be transacted at such special meeting.

#### Section 3 Admission to Meetings.

a. Admittance to any annual meeting shall be by an official name badge, or by guest badge. Admission fee for an annual meeting will be determined by the meeting planner in conjunction with the Treasurer with the approval of the Executive Council.

#### Section 4 Guests.

a. A guest shall be defined as any non-5 of the Academy.

b. A guest is not permitted to operate at an annual meeting. The Executive Council shall determine in its sole discretion if there shall be any limit to the number of guests who may be invited to attend any annual meeting.

b. Spouses, and significant others who are not dentists, and dental students, shall be considered as guests, and shall be exempt from the meeting fee, but not from social function expenses. The fee for other categories of guests for the meeting shall be determined by the Executive Council.

#### Section 5 Chair Clinicians.

a. It shall be required of every operator who shall present a chair clinic at a meeting of the Academy, and that he shall demonstrate to the Vice-President that there is adequate proof of a policy of malpractice insurance and appropriate licensure credentials available.

b. Any and all operators at the Annual Meeting shall be required to register for the meeting and pay the appropriate registration fees.

#### Section 6 Compensation to Essayists or Clinicians.

a. Anyone who is invited to present a paper or clinic at a meeting of the Academy, including members of the Academy, may be compensated at the discretion of the Executive Council.

#### Section 7 Postponement of Annual Meeting

a. In case of extreme emergency the annual meeting may be postponed by a three fourths (3/4) affirmative vote of the Executive Council, provided that written notice of such postponement is sent to all members of the Academy immediately following the action of the Executive Council.

#### Section 8 Notification to Membership

a. At least thirty (30) days prior to the annual meeting, it is the duty of the Secretary to report to the Academy membership those names proposed for membership, the slate proposed by the Nominating Committee and proposed changes to the Constitution and By-Laws.



## CHAPTER IX

### PRINCIPLES OF ETHICS

Section 1 The Principles of Ethics of this Academy shall not be in conflict with the Principles of Ethics of the American Dental Association.

## CHAPTER X

### PROCEDURE AT MEETINGS

Section 1 The order of business at the annual and special meetings of the Academy may be as prescribed by the discretion of the Executive Council.

Section 2 Except as otherwise specifically provided herein, a majority of the Active members in good standing, present and voting, at a meeting duly called, may transact the business of the Academy.

Section 3 The current edition of Roberts Rules of Order shall govern on points not covered herein.

## CHAPTER XI

### AMMENDMENTS

Section 1 These By-Laws may be repealed, altered or amended at any annual meeting by a two-thirds (2/3) vote of the legislative body present and voting, provided that notice of such proposed amendment shall have been submitted in writing to the members entitled to vote, at least thirty (30) days prior to the date of the meeting at which the amendment is to be presented.

## COMMITTEES

### SCIENTIFIC SESSIONS

Dr. Bruce Small, Chairman  
Dr. Alfred LaPorta

### EDUCATION AND CLINICAL SEMINARS:

Dr. Alfred LaPorta, Chairman  
Dr. Robert H. Bridgeman

### NOMINATING:

Dr. Marc Tollefson, Chairman  
Dr. Janet Zinter  
Dr. Dan Henry  
Dr. Wendell Foltz  
Constitution and Bylaws:

Dr. Barry Evans, Chairman  
Dr. Wendell Foltz  
Dr. Mel Lund

### INTER-ACADEMY LIAISON:

Dr. Alfred LaPorta, Chairman  
Dr. Susanne Grennell  
Dr. Bruce Small  
Distinguished Member:  
Dr. Barry Evans, Chairman  
Dr. Fred Eichmiller  
Dr. Tim Carlson

### OUTSTANDING CLINICIAN AWARD:

Dr. Bruce Small, Chairman  
Dr. Tasha Bollermann

### ANNUAL MEETING FACILITATOR:

Dr. Elaine Neal  
Elaine.neal1@gmail.com