INTERFACE RESIDUAL STRESSES IN DENTAL ZIRCONIA USING LAUE MICRO-DIFFRACTION

Hrishikesh A. Bale\textsuperscript{1}, Jay C. Hanan\textsuperscript{1}, Nobumichi Tamura\textsuperscript{2}, Martin Kunz\textsuperscript{2}, Paulo Coelho\textsuperscript{3}, Van Thompson\textsuperscript{3}

\textsuperscript{1}Oklahoma State University, Stillwater, OK; \textsuperscript{2}Advanced Light Source, Berkeley, CA; \textsuperscript{3}New York University, New York, NY.

Due to their aesthetic value and high compressive strength, dentists have recently employed ceramics for restoration materials. This change is in contrast to the previous five decades when dental restorations were principally composed of high noble alloys such as gold-platinum, gold-palladium, and silver-palladium. Typical structural ceramics in modern dentistry include alumina and zirconia in coordination with metals as metal-ceramic crowns, or veneered with porcelain. Among the ceramic materials, zirconia provides high toughness and crack resistant characteristics due to its intrinsic behavior of stress induced crystallographic transformation. The phase transformation from tetragonal to monoclinic produces local volume expansion favoring crack closure resulting in additional strength.

Residual stresses develop in processing due to factors including grain anisotropy and thermal coefficient mismatch. These residual stresses also influence the phase transformation. Quantitative determination of residual stresses in zirconia is challenging. Along with stress induced phase changes, grain-grain stresses are significant; and for application to dental materials, local variations from edges and surfaces are important. It is at these surfaces where bonding to the veneer takes place. In the present study, polychromatic X-ray (Laue) micro-diffraction provided grain orientation and residual stresses on a clinically relevant zirconia model ceramic disk. The ceramic disks were fabricated at a dental research laboratory maintaining thermal history, layer thickness, and finishing parameters found in typical clinical restorations. A 0.5 mm by 0.012 mm region at a 500 nm scale was observed.

Due to the symmetry in the tetragonal phase, 8 to 10 high intensity reflections were seen as compared to the monoclinic phase, in which, around 20 to 30 lower intensity peaks were observed. The deviatoric strains developed within zirconia were determined by indexing and fitting the peaks from the tetragonal phase of zirconia. A representative powder was used as a strain free reference. The analysis reveals a normal distribution of the residual stresses, with a mean compressive residual stress. A small fraction of localized compressive and tensile stresses reached 1 GPa, more than twice the mean stress. The above results on neat zirconia are compared to interface residual stresses caused by the thermal coefficient mismatch on a similar area veneered with porcelain.
The abstract is submitted for the ICRS conference.
▼ Permission granted to post abstract on the DXC web site and affiliated web sites.
▼ Speaker’s (contact’s) name:
   Jay Hanan
mailing address:
   Oklahoma State University
   700 N. Greenwood Ave.,
   Tulsa, OK 74106
   phone number: 918-594-8238
   fax number: 918-984-8558
   e-mail address: Jay.Hanan@okstate.edu

session where paper may be best suited:

**Synchrotrons: Microbeam Techniques**

▲ Present in ICRS evening poster session

▼ Intend to publish this paper in the ICRS proceedings.