Hydroxide-Assisted Bonding of Ultra-Low-Expansion Glass

Preparation of bond surfaces is critical to success.

NASA's Jet Propulsion Laboratory, Pasadena, California

A process for hydroxide-assisted bonding has been developed as a means of joining optical components made of ultra-low-expansion (ULE) glass, while maintaining sufficiently precise alignment between. The process is intended mainly for use in applications in which (1) bonding of glass optical components by use of epoxy does not enable attainment of the required accuracy and dimensional stability and (2) conventional optical contacting (which affords the required accuracy and stability) does not afford adequate bond strength.

The basic concept of hydroxide-assisted bonding is not new. The development of the present process was prompted by two considerations: (1) The expertise in hydroxide-assisted bonding has resided in very few places and the experts have not been willing to reveal the details of their processes and (2) data on the reliability and strength attainable by hydroxide-assisted bonding have been scarce.

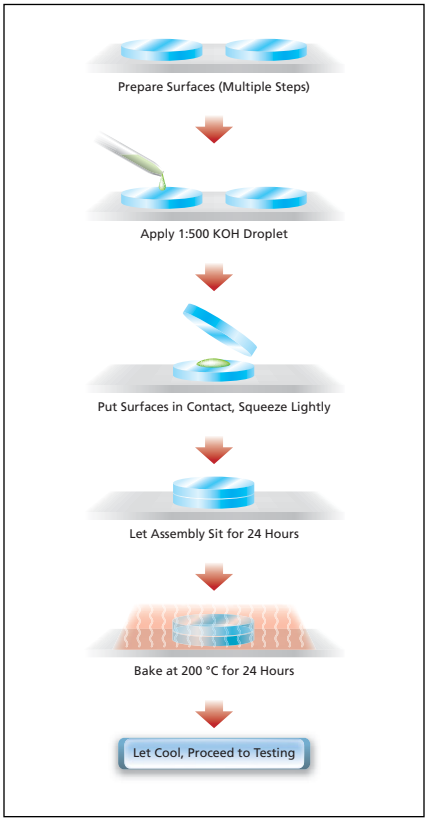
The first and most critical phase of the present hydroxide-assisted-bonding process is the preparation of the surfaces to be bonded. This phase includes the following steps:

2. Ultrasonic cleaning in successive baths of acetone, methanol, and propanol, using an ultrasound cleaner that operates at several Megahertz (Megasonics).
3. Treatment in a solution of potassium hydroxide and ammonium hydroxide in an ultrasonic cleaner, at Megahertz frequencies.

Thorough rinsing with deionized water is carried out after each of the above-mentioned steps. The last rinse is followed by ultrasonic cleaning in deionized water, then the cleaned surfaces are blow-dried with ionized air.

After preparation of the surfaces as described above, a droplet of a dilute solution of potassium hydroxide is placed on one of the surfaces, then the surfaces are placed in contact and gently squeezed together (see figure). The resulting assembly is allowed to sit at room temperature for 24 hours, and is then baked at a temperature of 200 °C for 24 hours.

In mechanical tests, sample bonds made by this process were found to have tensile strengths of at least 1.3 kpsi (≈9 MPa), where the epoxy bond used to attach the sample to the tensile stress test apparatus broke.



Two Prepared Surfaces are placed in contact with a small amount of a hydroxide solution at the interface. The assembly is allowed to sit and is then baked. The resulting bond is at least as strong as an epoxy bond.

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Photochemically Synthesized Polyimides

Single monomers are polymerized by exposure to ultraviolet light, without heating.

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An alternative to the conventional approach to synthesis of polyimides involves the use of single monomers that are amenable to photopolymerization. Heretofore, the synthesis of polyimides has involved multiple-monomer formulations and heating to temperatures that often exceed 250 °C. The present alternative approach enables synthesis under relatively mild conditions that can include room temperature.

The main disadvantages of the conventional approach are the following:

- Elevated production temperatures can lead to high production costs and can impart thermal stresses to the final products.
- If the proportions of the multiple monomeric ingredients in a given batch are not exactly correct, the molecular weight and other physical properties of the final material could be reduced from their optimum or desired values.

To be useful in the alternative approach, a monomer must have a molecular structure tailored to exploit Diels-Alder trapping of a photochemically generated *ortho*-quinodimethane. (In a Diels-Alder reaction, a diene combines with a dienophile to form molecules that contain six-membered rings.) In particular, a suitable monomer (see figure) contains *ortho*-methylbenzophenone con-