Fusion Bonding Recipes for Glass-Glass Nanofluidic Devices

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Motivation
Thermal fusion bonding is the most effective way to make all-glass micro- and nanoscale devices with homogenous surface composition.

Objectives
- Develop an efficient, reliable fusion bonding recipe for the glass-glass structured devices with patterned nanochannels (at 50 nm in depth).
- Investigate the effect of experimental parameters (temperature and pressure) behind the glass-glass bonding process.
- Glass is a desired material in micro- and nanoscale device fabrication due to its optical clarity, chemical inertness and temperature stability.
- One of the most important applications for micro- and nanodevices is Lab-on-a-Chip(LOC) devices.
- Fusion (direct) bonding is the best approach to generate an enclosed channel with 4 chemically similar walls.
- Channel collapse/distortion are some challenges associated with fusion bonding.

Previous Reported Fusion Bonding Techniques
- Mao[1] achieved 90%-95% bonding area by:
  - Piranha for 10 mins.
  - 28% ammonium hydroxide at 50 °C for 30 mins.
  - Spin dry, align.
  - Press glass wafers with 5b weights for a few hours.
  - 650 °C for 12-18h with ramp rate of 1.0-1.5 °C/min and cool down rate of 1.5 - 2.5 °C/min.
- Allen and Chiu’s [2] found out that using calcium acetate removes a key bottleneck in fusion bonding.
  - Treatment with Alconox (0.5%) and calcium acetate (30 mM).
  - ~ 4 kg weight of polished alumina.
  - 100 °C (heat at 0.3 °C/min).
  - 625 °C (heat at 4 °C/min) hold for 1 h.
  - Cool to 50 °C (slower than 2 °C/min).

Design & Methods
Figure 1. 3D view of the device

Experimental Procedures
1. Glass slides pre-processing.
   (Cleaning and glass surface activation steps).
2. Slides assembly.
3. Programming set up and fusion bonding cycles.
4. Sample analysis.
   (Leakage test; Bond stress and Optical properties).

Successful parameters
- Setpoint temperature = 600°C.
- Time at setpoint temperature = 600 mins.
- Ramp up rate = Ramp down rate = 1 °C/min.
- Applied pressure = 9.3 KPa.
- Calcium assisted surface activation.

Results

Summary & Conclusions
- Our results indicate that sealed glass-glass channels can be bonded at a temperature of 600°C over 10 hours along with simultaneous application of weight over the bonding area (a load of 1.14 kg corresponds to a pressure of 9.3 kPa applied over the entire area of the channel containing cover glass).
- Poor bonding is observed at lower set point temperature and when weight is not applied.
- Cracking of glass is seen when the load is increased.
- Our initial results showed that the use of calcium ion removes a key bottleneck in fusion bonding.

Future Work
1. Repeat ammonium hydroxide activation step [1] and calcium acetate activation [2].
2. Achieve fusion bonding for glass-glass nanofluidic devices with embedded metal electrodes.
3. Develop fusion bonding recipe for the glass-glass structured devices less than 50 nm in depth.

References

Further Information
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Acknowledgements
The author would like to thank Kaushik Rangharajan and Emily Rosenthal-Kim for their help and guidance throughout the project. The author would also like to thank my fellow MSNS lab mates, who have provided a lot of suggestions, constructive criticism, and encouragement.