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# Silicate Bonding Research at Caltech

**Helena Armandula**

**Caltech**

**LSC Meeting**

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# Hydroxide-catalysis bonding

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**In the Advanced LIGO Interferometer, the masses will be suspended by silica fibers or ribbons.**

**Fibers or ribbons will be welded to prisms attached to the masses.**

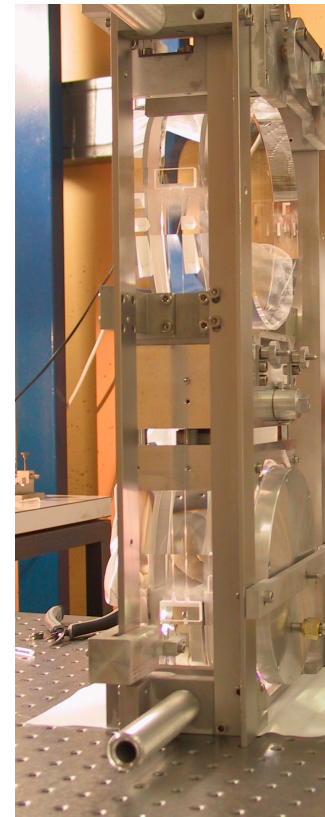
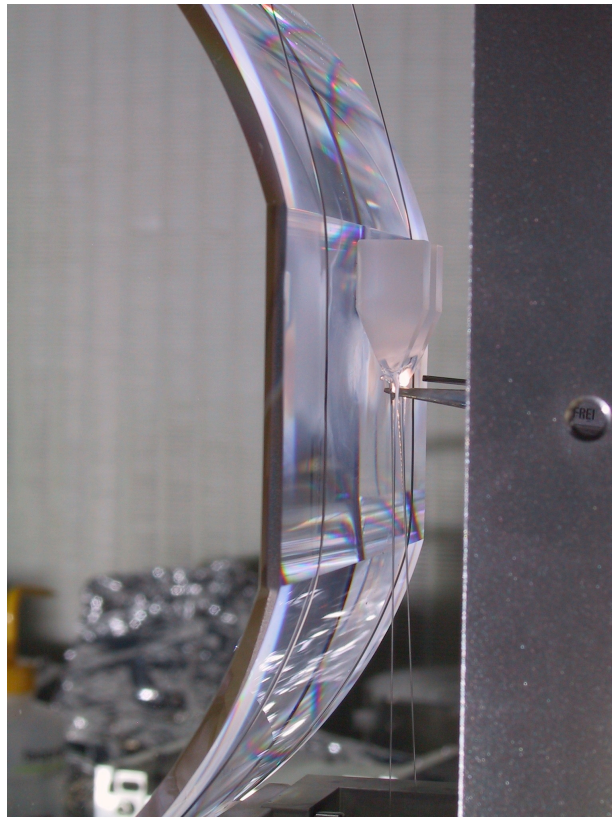
**Silicate bonding will be used to attach prisms to masses.**

**Hydroxide-catalysis bonding is the process by which an hydroxide (K or Na in our application) catalyzes a silica surface by hydration and dehydration.**

**Because the surfaces are required to be in close contact to bond, a flatness of 1/10 wave is desired to maximize bond strength.**

# Prisms and Fibers

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# Tools to Characterize Bonds

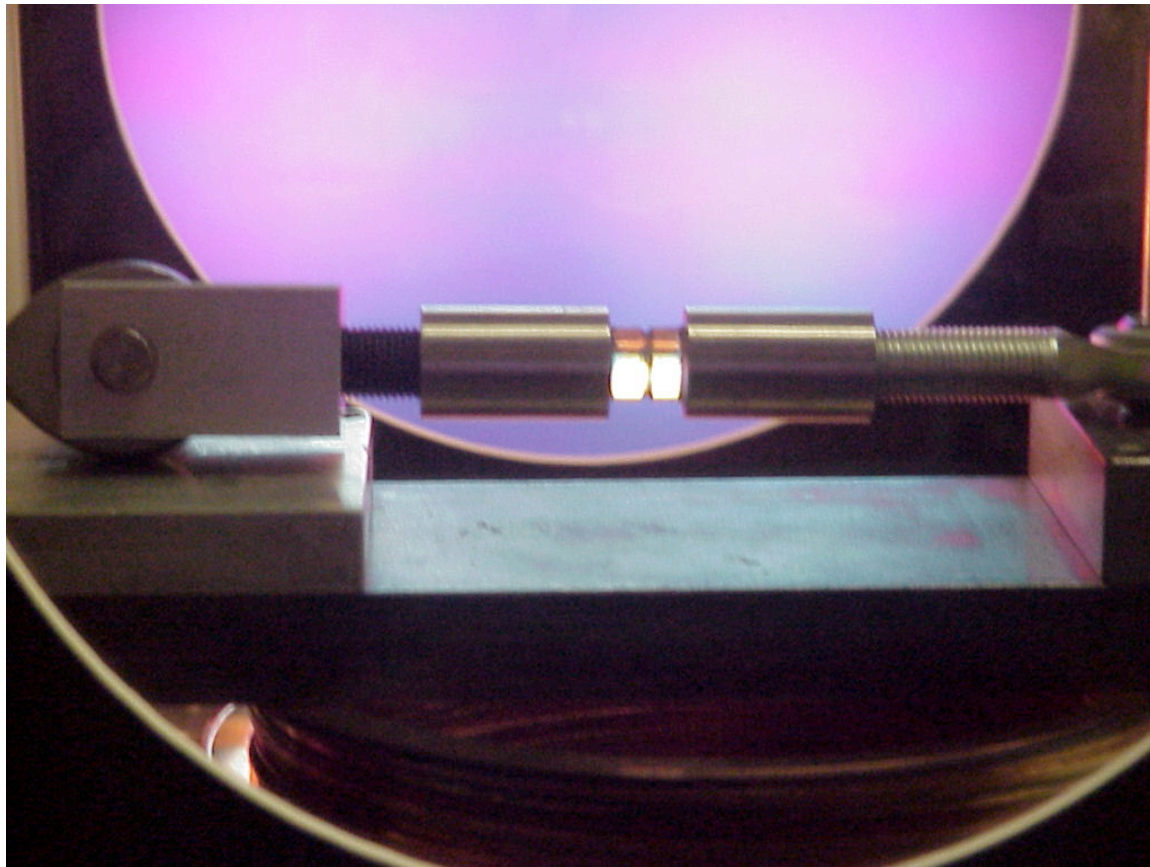
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- As a tool for non-destructive testing we acquired a polariscope to observe stress on bonds.
- Built a pull tester (destructive test) to test tension strength
- Set up a test station to test shear strength



# Polariscope and Pull Tester

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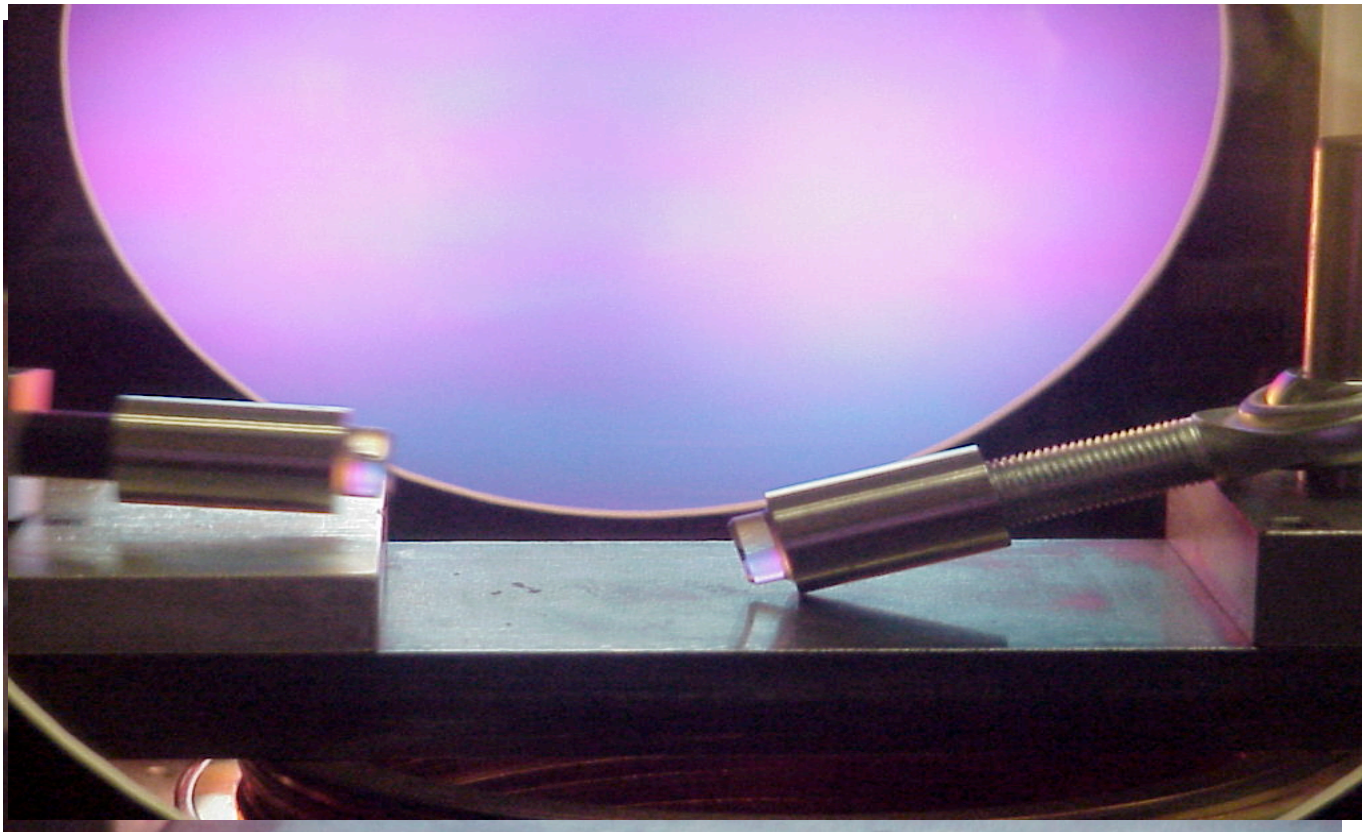


*LIGO-G030408-00-D*



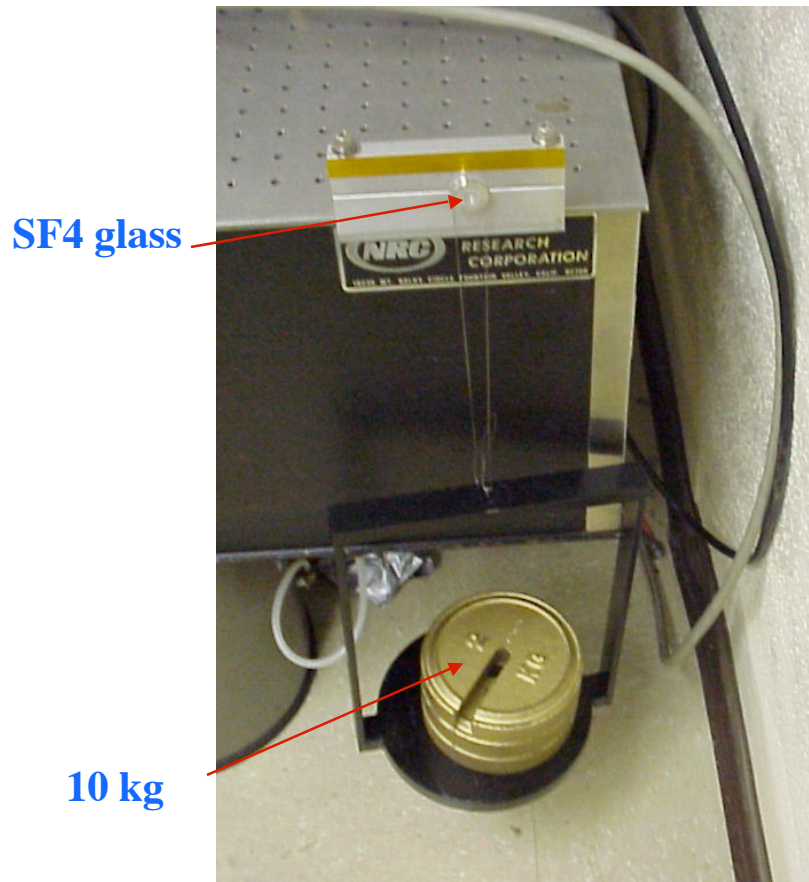
# Polariscope and Pull Tester

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*LIGO-G030408-00-D*

# Shear Test



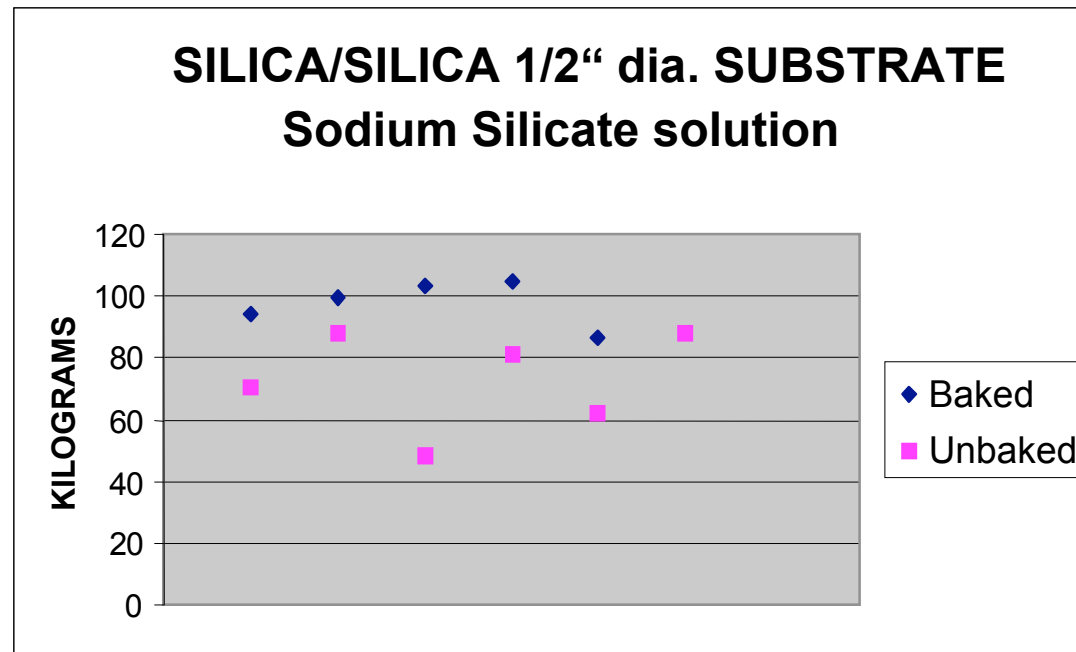
- Under test ~20mm bonded area holding 10kg, as shown.
- Advanced LIGO test masses are 40kg suspended on 4 silica fibers
- Size of bonded area not yet determined.



# Silica / Silica Bonds

(Baked / Unbaked)

Bonds were baked at 120 degrees C for 24 hours





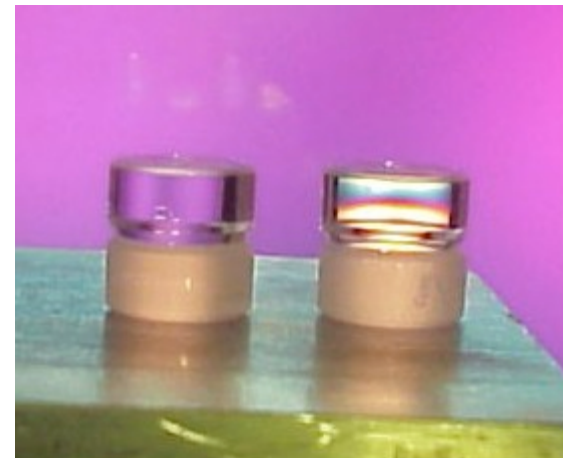
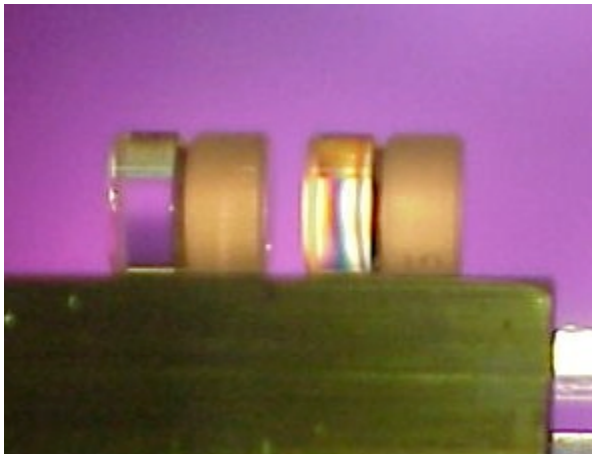


# Baked / Unbaked Silica/Sapphire Bonds

**Stress could be observed on the silica/sapphire baked bonds.**

**(Baked bond shown at right.)**

**Bonds baked the same day they were manufactured.**





# Silica / SF4 Glass

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- Testing underway

## **Tension tests on unbaked bonds**

1. SF4-2 (3 mo. old) was pulled up to 61 kg (tension)
2. SF4-6 (3 mo. old) was pulled to 54 kg (tension) – broke from holder
3. SF4-1 (3 mo. old) has been under 26 kg (tension) since 1-16-03 – exposed to 30.5 ° C for 24 hr on 1-30-03. There was no sign of stress on the bond.

## **Sheer tests on unbaked bonds**

1. SF4-5 (3 mo. old) loaded with 4.5 kg for 8 days, increased weight to 6.5kg, then 8.5 kg and 10.5 kg on February 3<sup>rd</sup>. The bond broke around February 18<sup>th</sup>.
2. SF4-9 (2 mo. old) loaded with 10.5 kg on March 5<sup>th</sup>, still loaded.



# Silica / SF4 Glass

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- Baking Tests

Baked 4 substrates to 85° C for 1 hr.

One of the parts broke due to stress.

The other 3 parts showed stress while warm, however, unlike the sapphire/silica bonds, where stress remained when the parts cooled, the stress on the SF4 / Silica bonds disappeared.

Strength tests on baked bonds are to be performed soon.



# Polariscope and Pull Tester

