

Measuring Bond Strength of Capsule to Fill Tube Assembly (CFTA) at Cryogenic Temperatures

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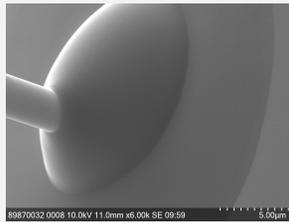
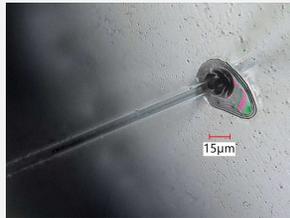
Motivation

- Current method can measure glue bond strength, but method is limited
- New adhesives and curing process may affect bond strength
- New method is designed to directly measure CFTAs for more accuracy
- Tests are performed with appropriate configuration and temperature

Introduction

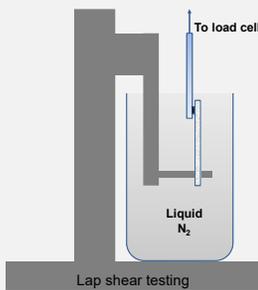
Extremely small CFTA bond presents challenges

- Small quantity of adhesive in a CFTA (~5pL)
- Fragile CFTA can fail during handling/test set-up at room temperature (293K)
- Cooling is of interest because targets are fielded at 19K
- Liquid nitrogen at 77K is representative of NIF shot temperature
- Difference in CTE of materials can produce mechanical stress while cooling



Adhesive bond of interest where fill tube is attached to capsule at fill hole

Adhesives can be qualified for bond strength using lap-shear testing



- Strength of UV curable glues measured with lap shear method
- Glass slide adhered to aluminum coupon and pulled to failure
- Normalized bond strength obtained by force at failure/surface area
- Can be submerged in liquid nitrogen
- Glass on aluminum is not representative of CFTA materials
- Bond strength is dependent on size, especially at cryogenic temperatures

- Great method to qualify adhesives
- Does not directly correlate to CFTA bond strength

Materials and Methods

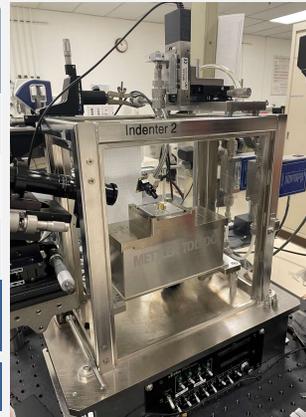
Specialized system was set-up to measure pL bond assemblies

- System has a sensitive load cell and precision-controlled translation
- Tests performed at room temperature in a humidity-controlled chamber

Fill tube Diameter	Average Failure (g)	Standard Deviation
2 µm (n=33)	0.88	0.49
5 µm (n=7)	1.14	0.49
10 µm (n=14)	4.08	1.92

Average failure of CFTA bond at room temperature measured on the custom tensile tester

(Right) Custom tensile tester with experimental set-up



- Tests performed at room temperature do not indicate the CFTA behavior at cryogenic conditions where significant thermal stresses arise

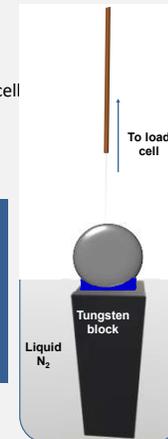
New method for measuring cryogenic bond strength of CFTAs

- Strength of CFTA at fielding conditions (19 K) is realistically represented at 77K as most of the contraction is complete
- System designed to be simple and effective
- Minimal handling
- Custom fixture made to attach CFTA directly to load cell



(Left) 5 N Load cell with custom fixturing to directly mount CFTA with VCR fitting

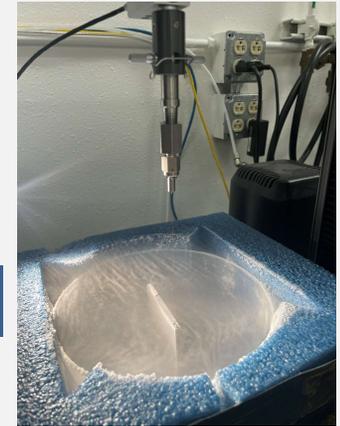
(Right) Test design diagram. Capsule is secured to tungsten block with Stycast 2850 fillet before measurement



Results and Conclusions

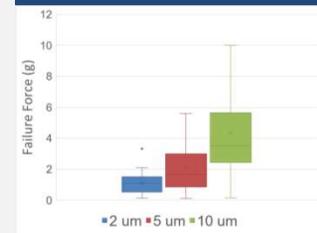
First ever CFTA cryogenic measurements provide fresh insights

- Capsule temperature verified
- Two cure mechanisms investigated
- Two failure modes observed: tube pull-out and tube fracture
- Significant net strength despite thermal stresses from CTE mismatch of thermal contractions

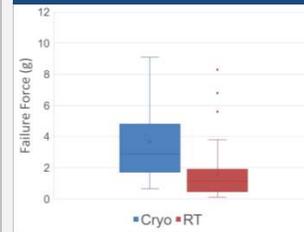


(Right) Tensile tester with experimental set-up during liquid nitrogen cooling

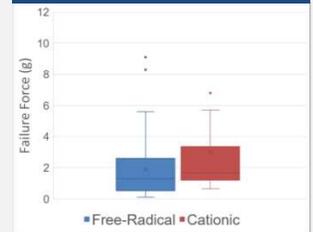
Bond strength dependent on fill tube diameter



CFTA bonds fail at higher force at cryogenic temperatures



Cationic cure glues comparable if not better in strength



A new method to measure the bond strength of CFTAs has been developed. It has shown reproducible results at both room and cryogenic temperatures. This new method has provided insights for the CFTA assembly parameters including adhesive type and cure conditions.