

Cooled Carbon Detector Support

FNAL PO 537534 (Apr 2001)

Development Review

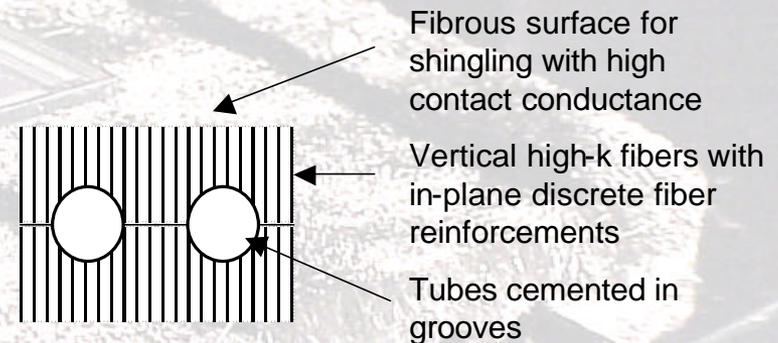
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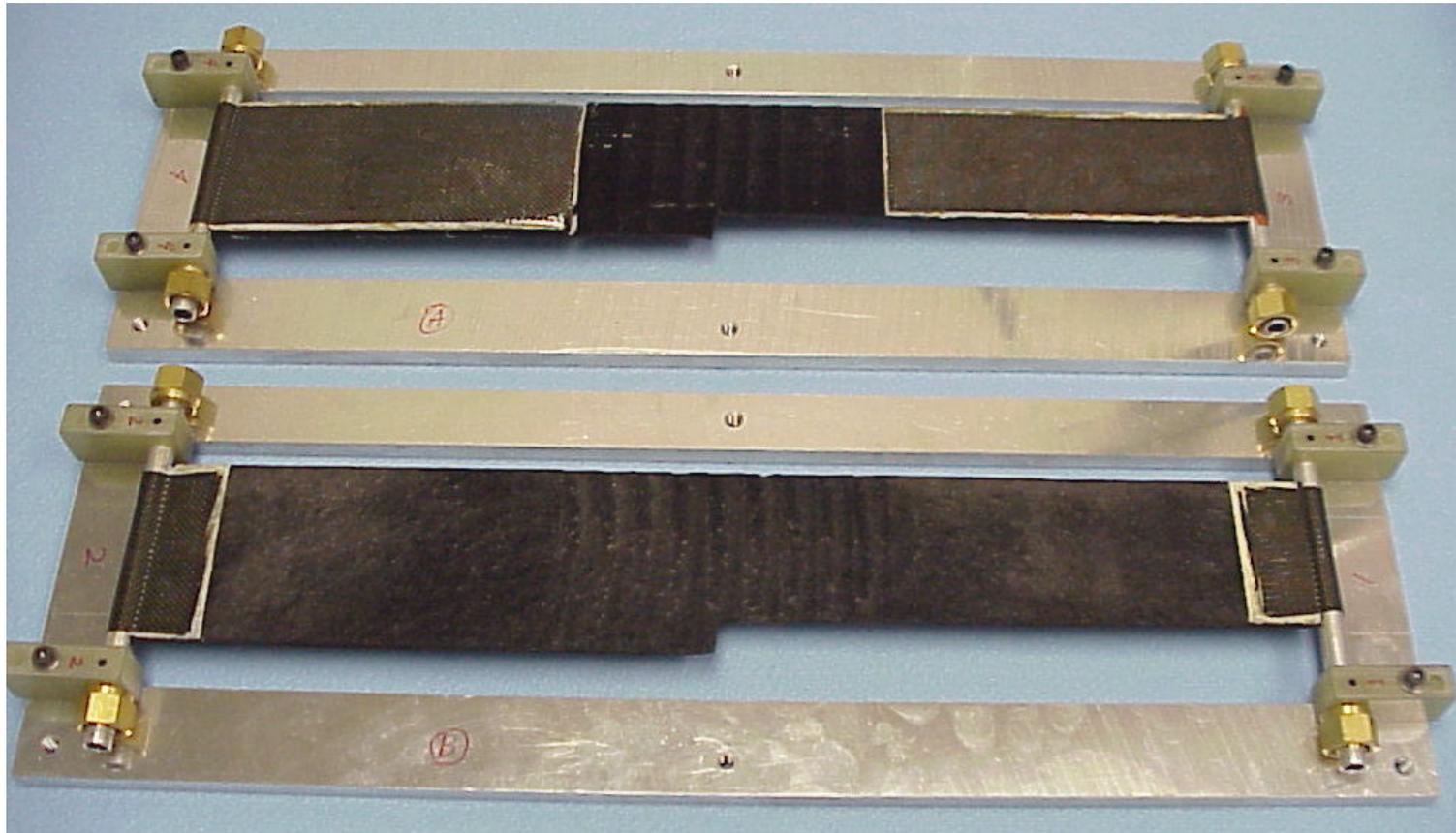
- FY00 Developments
- Objectives of FY01 effort (Phase 1)
- Radial fiber orientation with improved bonding
- Ovalized tubing arrays
- Leaktight joining of carbon tubes
- Toughening carbon joints
- **Carbon manifolding**
- Coupon demonstration
- Phase 1 Conclusions
- Phase 2 Recommendations

FY00 Architecture

- Cooled carbon structure demo articles (full-scale)
 - Lightweight
 - Rigid
 - Shingled surface
 - Porous chip mount
 - Al manifolds
- Issues
 - Resistance at tube wall is high
 - Need to increase thermal conductance
 - Tubing cracked, leaked
 - Need to increase toughness and assure leak-tightness



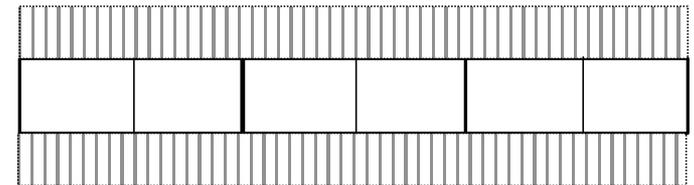
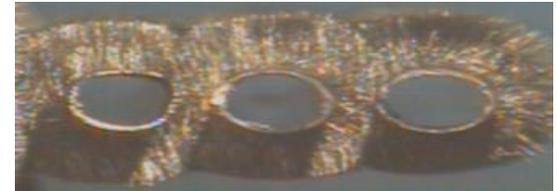
FY00 Demonstrations



60 cm $k = 6 \text{ W/m-K}$, $m = 0.11 \text{ g/cm}^2$

Increase Thermal Conductance

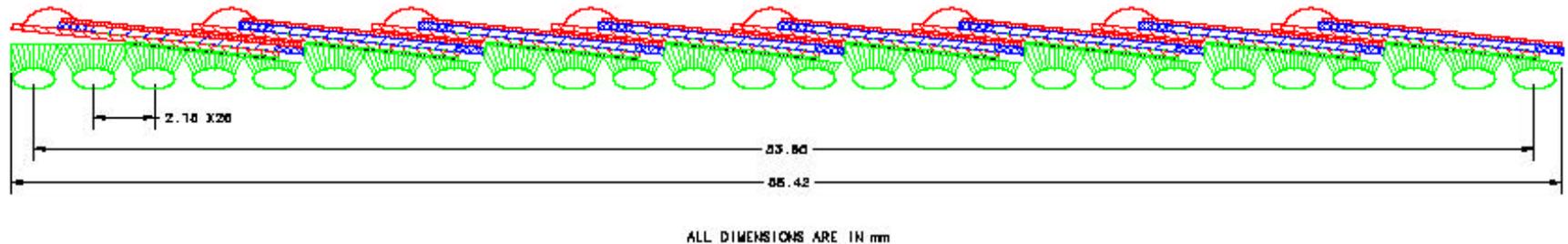
- “Fintubing” Concept
 - Improved fiber orientation
 - Issues: Precision? Manifolds?
- “Tubewall” Concept
 - Complete layer of tubing
 - Tubing height < 1 mm
 - Issues: Precision, Rigidity?
Manifolds



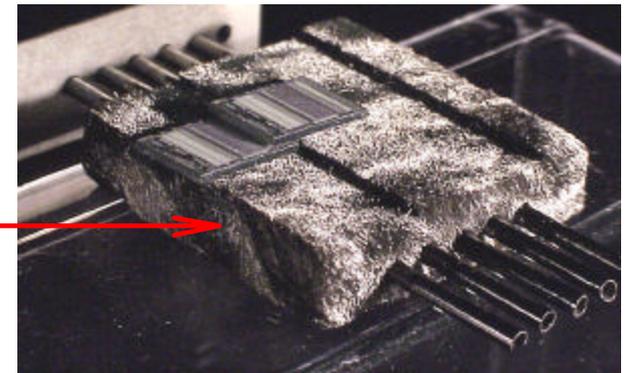
FY01 Development Plan

- Issues with FY00 Supports
 - Improve through-thickness thermal conductance
 - Strengthen/toughen carbon tubes at manifold junctions
 - Long parts may need greater rigidity
- Phase 1 – Coupon-scale demonstrations
 - Ovalize carbon tubing
 - Improve fiber architecture
 - Improve strength of manifold joints
- Phase 2 – Fabrication of two full-scale support planes
 - Incorporate latest design modifications by FNAL
 - Incorporate successful process developments by ESLI

FNLA Design – May 2001

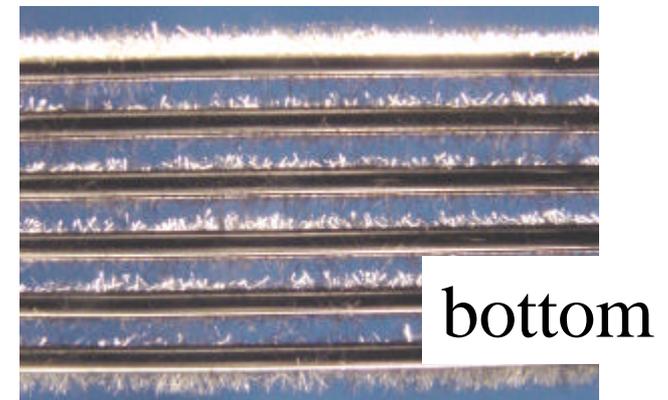
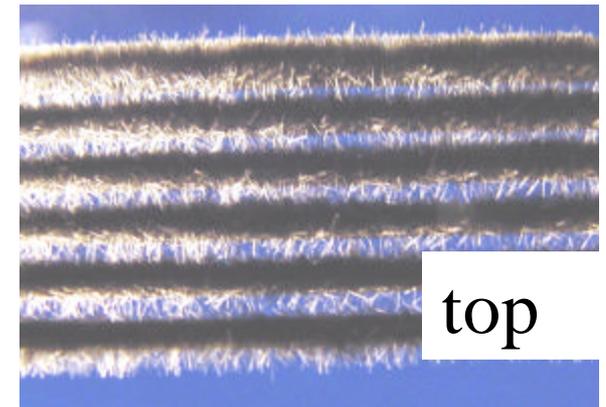
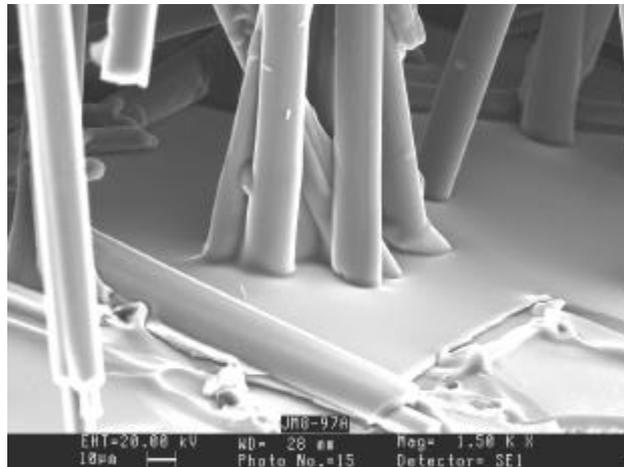


- Ovalized fintubing, congruent pitch
- Radial high-k fiber for more efficient conduction path
 - FY00 used vertical fiber



Radial Fintubing Array

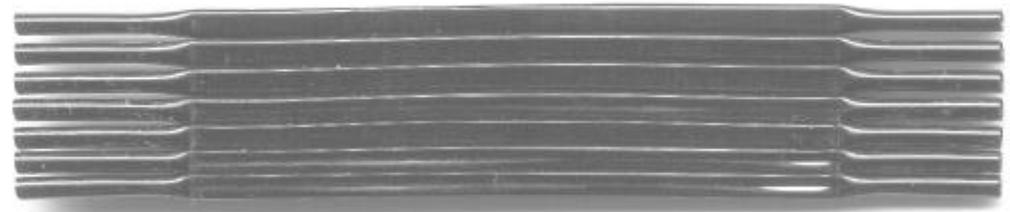
- High-k fiber electrostatically attached to carbon tubing is radially oriented and the fiber-tube bond is intimate



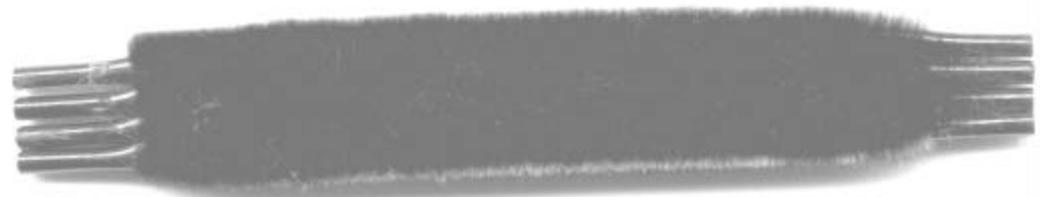
Note: Support would have fibers on both sides

Ovalized Tubing Array

- Ovalized carbon tubing precursor fuses together for greater stiffness
- Single layer of carbon fiber applied to flattened tubular panel should have high conduction efficiency

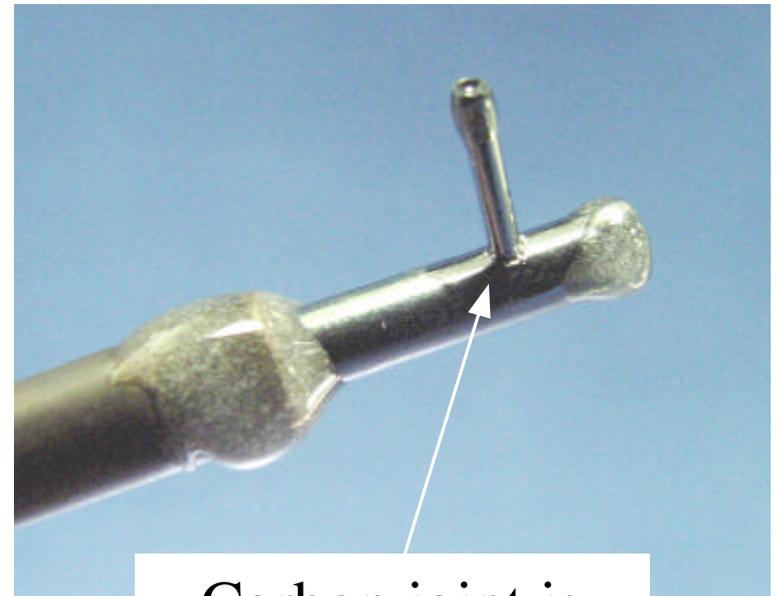


Integral plate



Leaktight Carbon Joint

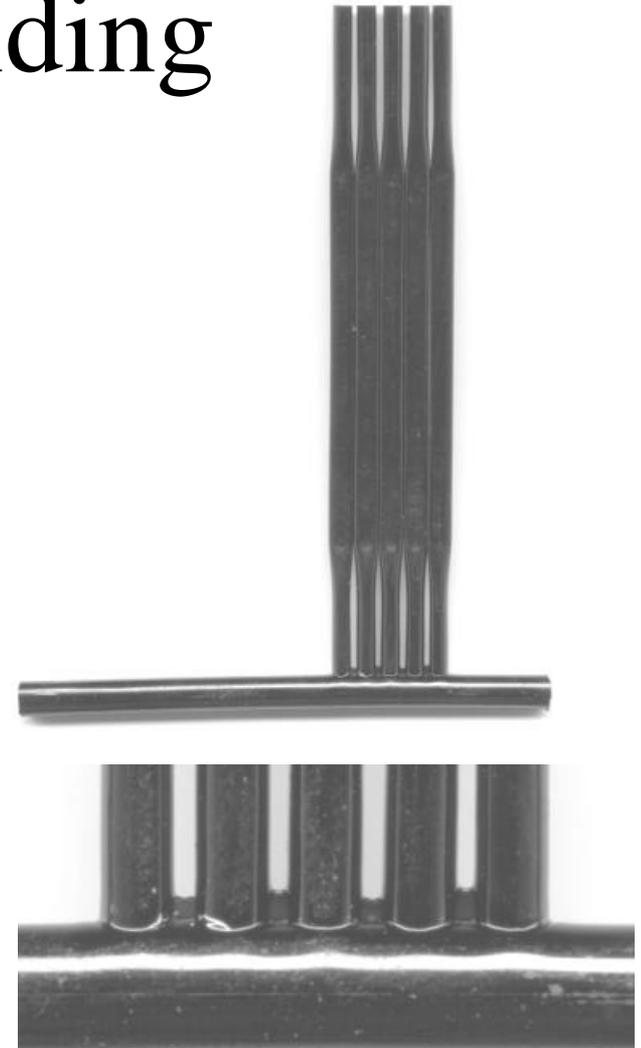
- Carbon T-joints formed between 1-mm and 4-mm tubes are leaktight ... but very fragile
 - Tube arrays share the stress and should be less fragile
- Perhaps a strain-relief material could be applied at the joints



Carbon joint is helium leaktight, but easily snapped

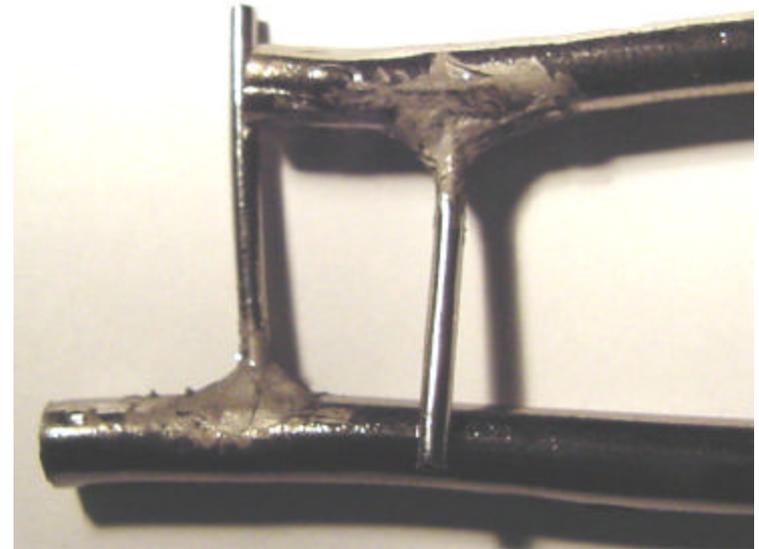
Carbon Manifolding

- This preform article shows
 - Ovalized tubing array
 - Tube-in-tube manifolding
 - Resin filler
- This part will shrink 20% during carbon processing
- Tooling must accommodate that scale change

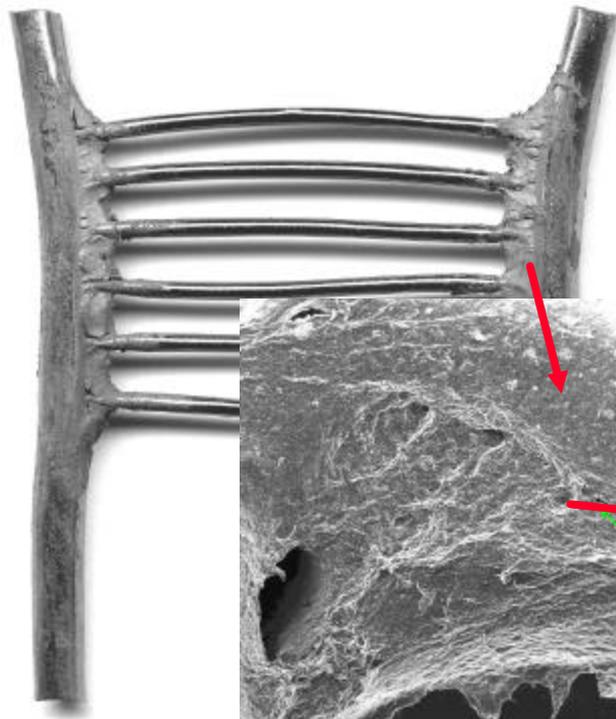


Toughening Paste

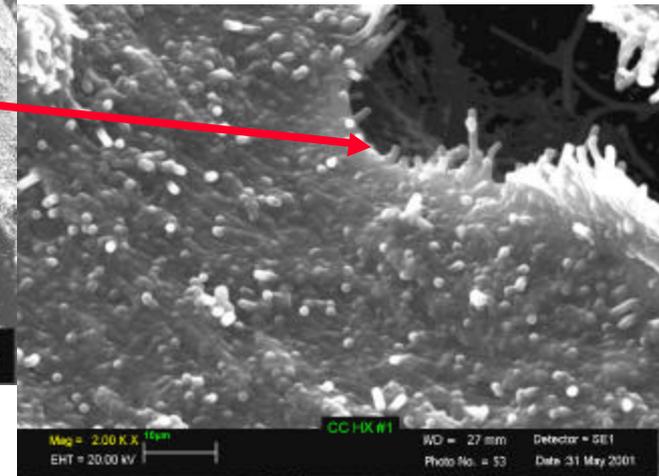
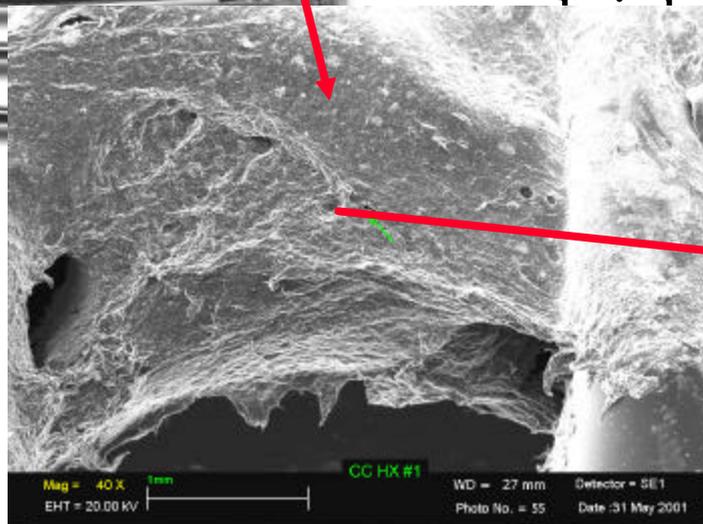
- Epoxy fillets would improve toughness and handleability of the parts
- For carbon fillets, we need something that will process thick and tough
- We investigated a “paste” composition formed with C-whiskers in carbonizable resin



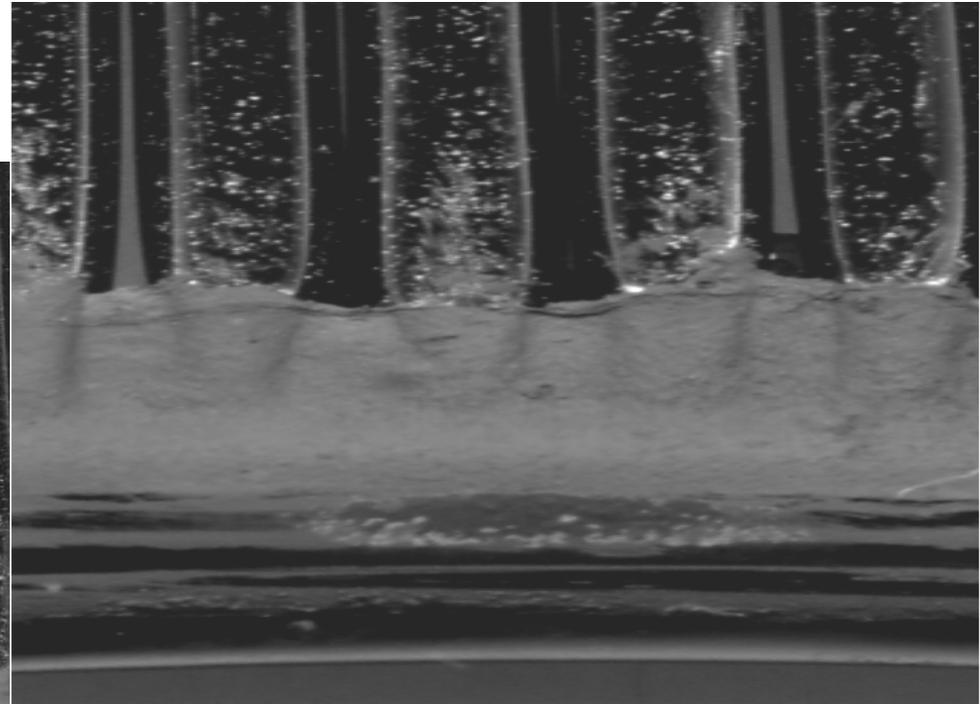
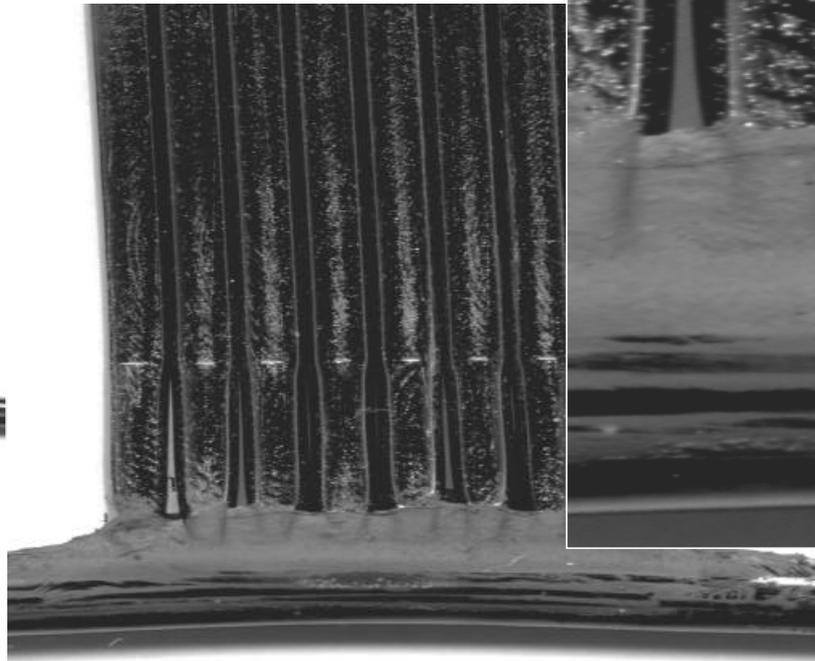
Carbon Strain Relief



- Carbon whisker paste is porous, adheres well to tubing, and appears suited for strain relief ... but large mismatch distorts shape

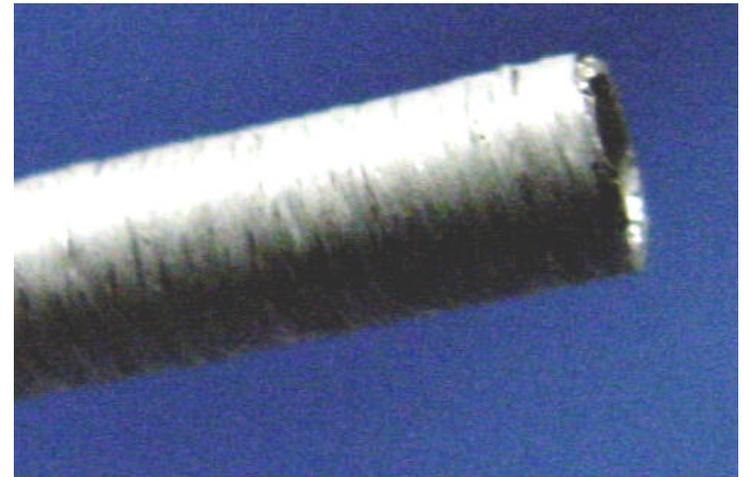


8-tube Manifold with Paste



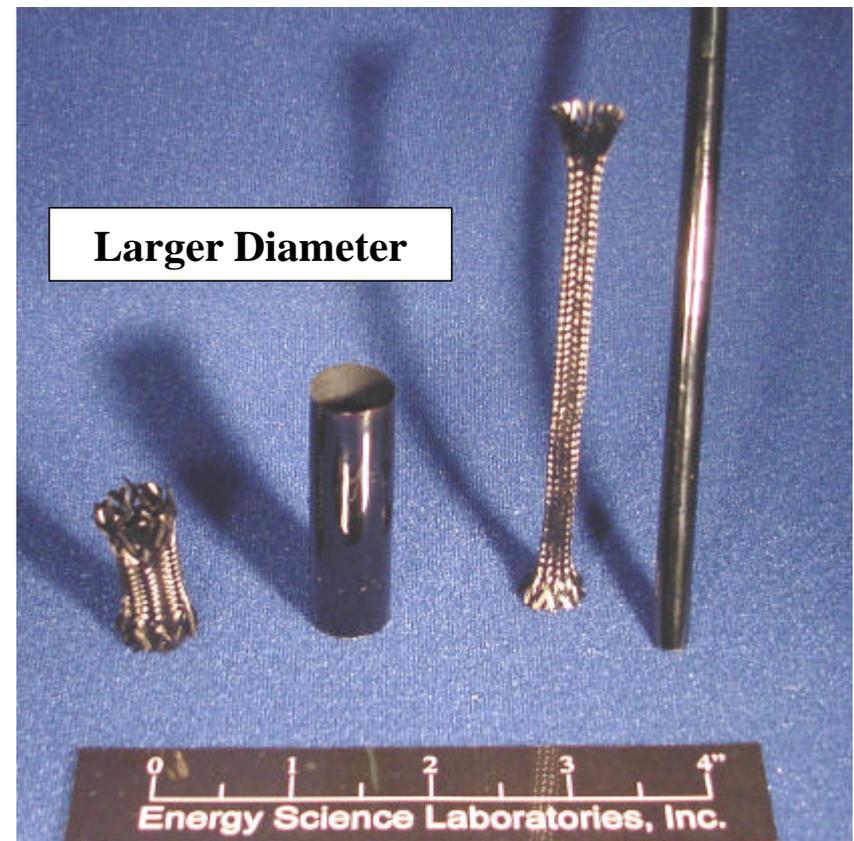
Filament Wound on ESLI Tubing

- Demonstrating feasibility of integrating carbon filament with ESLI carbon manifold lines
- Perhaps a lightweight means to increase strength and toughness



Reinforce Tubing with Braid

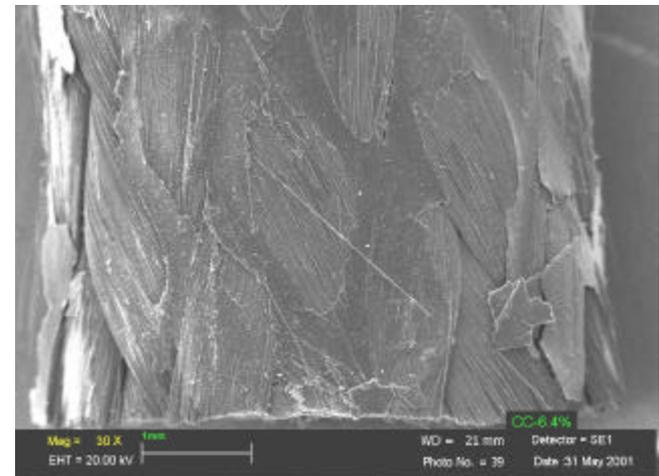
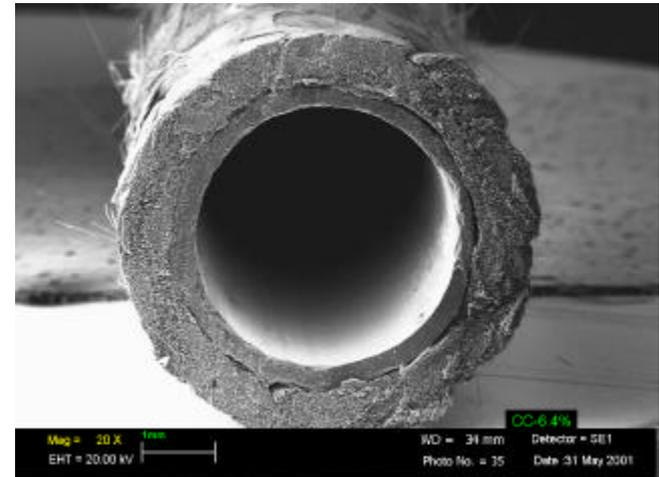
- Reinforcing braid applied to ESLI carbon tubing
 - Strong and tough
 - High modulus, low CTE
- Potentially useful for long carbon manifolds



Carbon Braid Reinforcement

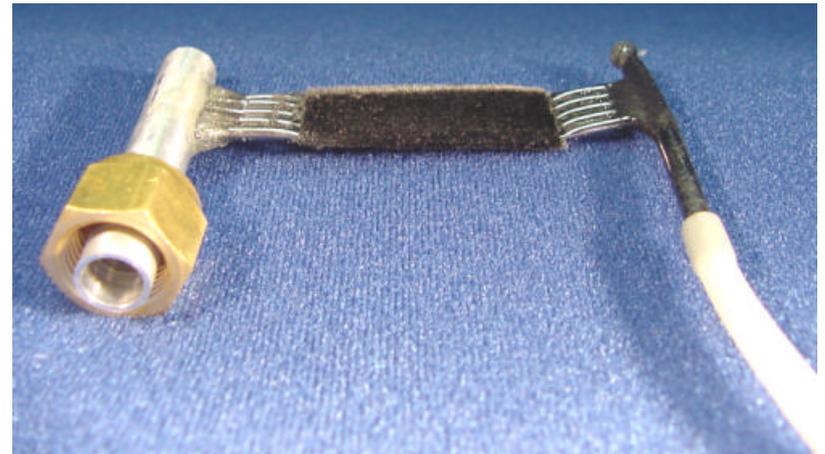
- Apply carbon braid to 4-mm carbon tube
 - Stronger and tougher, but heavier

Note: This braid is too thick for this tube, and the resin paste was too viscous



Coupon Test Article

- Carbon manifold bent during processing – inadequate tooling
- Aluminum manifold attached with epoxy
- Tiny leak in one of the five carbon tube/manifold joints sealed with epoxy



FY01 Development Summary

- Ovalized carbon tubing, fused into integral plate
 - Increases heat transfer area – should reduce Si temperature
 - Increases thermal effectiveness of carbon velvet layer
 - Increases in-plane torsional rigidity
 - 75-micron tube wall thickness ovalizes well without collapse
- Leaktight carbon manifolding, processed to high T
 - Demonstrated 4-mm ID x 4.5 mm OD
 - Recommend 7-mm ID x 7.5+ mm OD
- All carbon reinforcement “paste” seems to relieve stress and effectively toughen the manifold joints
 - Composite of C-whisker in glassy carbon precursor

Recommendations

- Fabricate FY01 Prototype having ...
 - Ovalized tube array
 - Carbon manifolds (short part)
 - Larger manifold lines with braid reinforcements
 - Strain relief fillets
 - Requires new tooling and tube fabrication
- Deliver two full-scale cooled carbon supports for thermal testing by FNAL