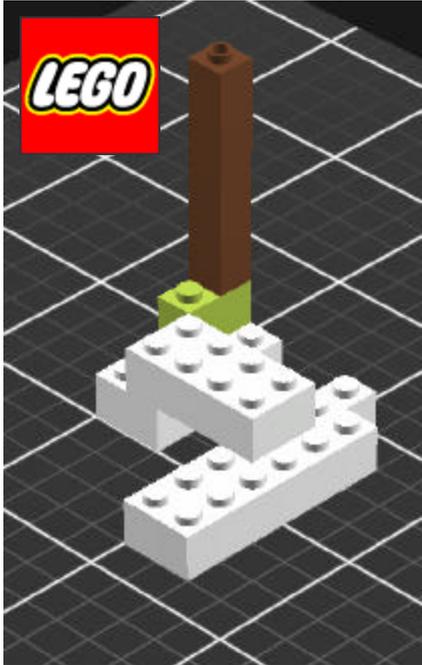


George A. Popescu
Prof. Neil Gershenfeld

Digital Materials and Digital Printers



Existing technologies



10 \$

Reversible

Low
precision
Assembly

Error
Correction



Age 3+

100 000\$

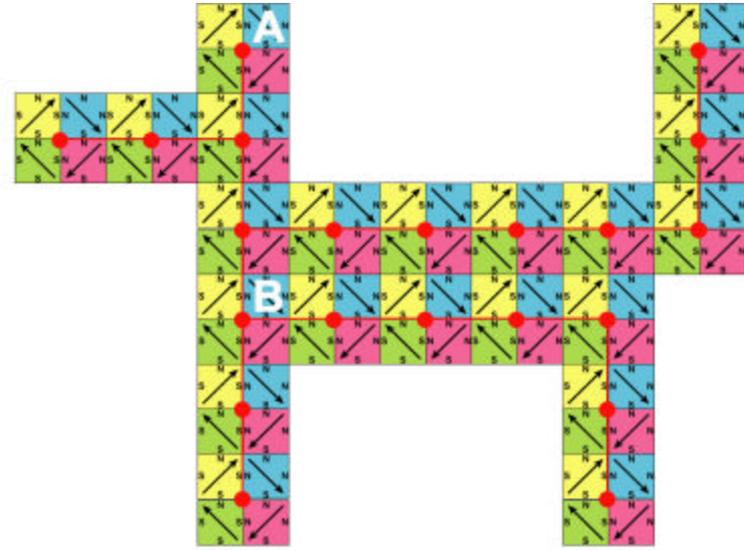
Irreversible



Age 21+

Existing Research :Saul Griffith

2D
Folding



(A) B:P:B:P:B : Y:B:Y:B:Y:B:Y:B:Y : G:Y:G:Y : B:P:B:P:B:P : G:P:G:P:G:P:G:P:G:P :
B : Y:B:Y:B:Y:B:Y:B : P:B:P:B:P : G : Y:G:Y:G : P:G:P:G:P:G:P : B:P:B:P : G : Y :
G:Y:G:Y:G:Y:G : P:G:P:G : Y : B:Y:B:Y : G:Y

2D
Programmable
Assembly



How to make Saul's Thesis at a micron ?

How to make 3D objects ?

GIK



Cut in 2D

Assembled in 3D

Space filling voxels

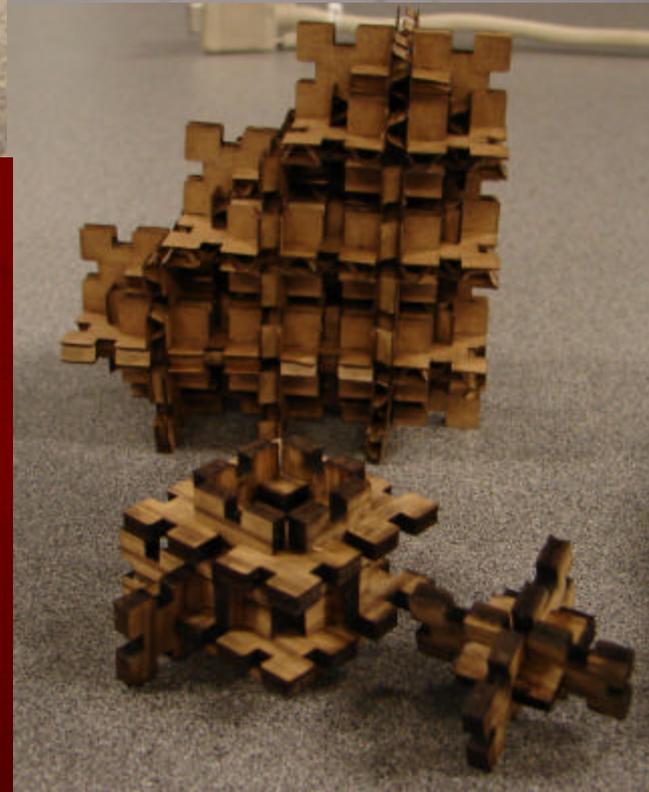
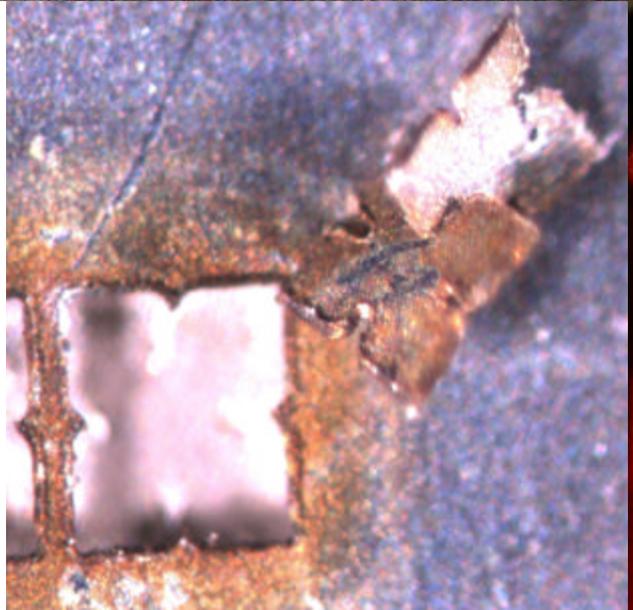
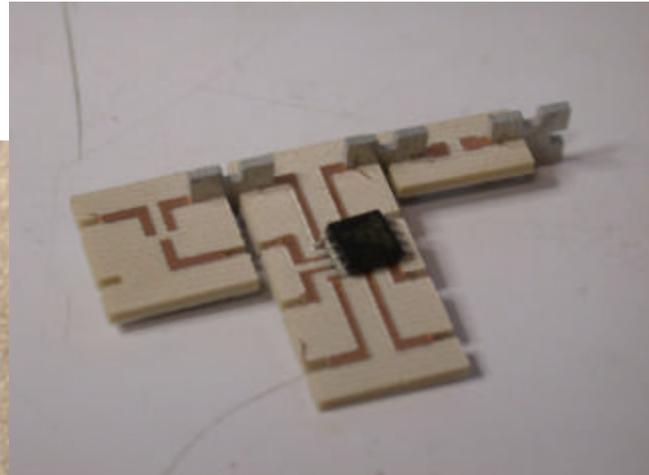
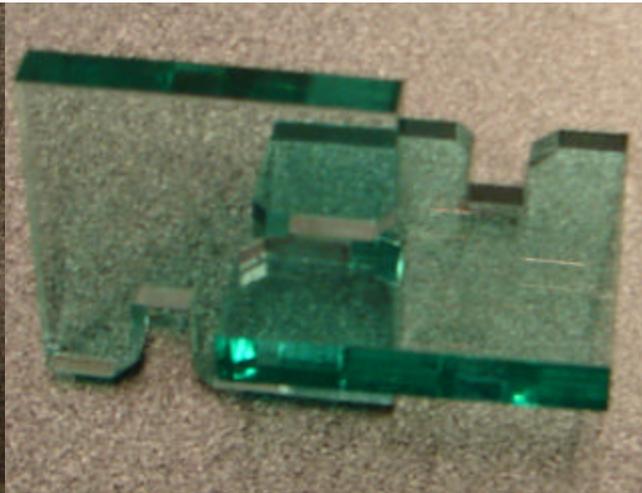
Press fit : reversible

Multiscale

Multimaterials

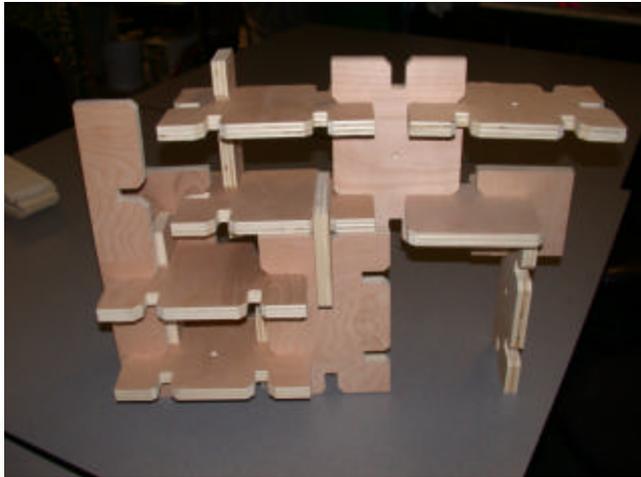
Material Set

Plexiglas, Stainless Steel, Foam, Plywood , Kepton ...

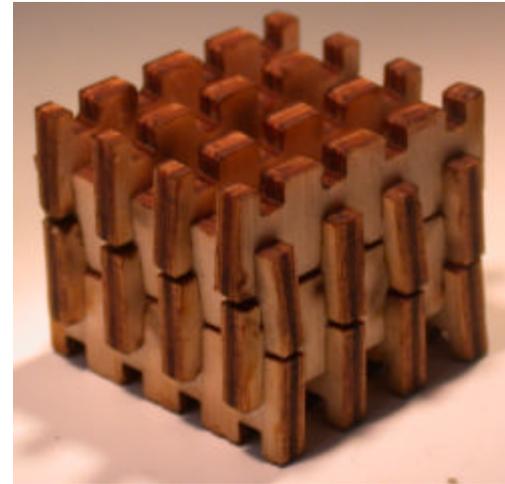


Multiscale

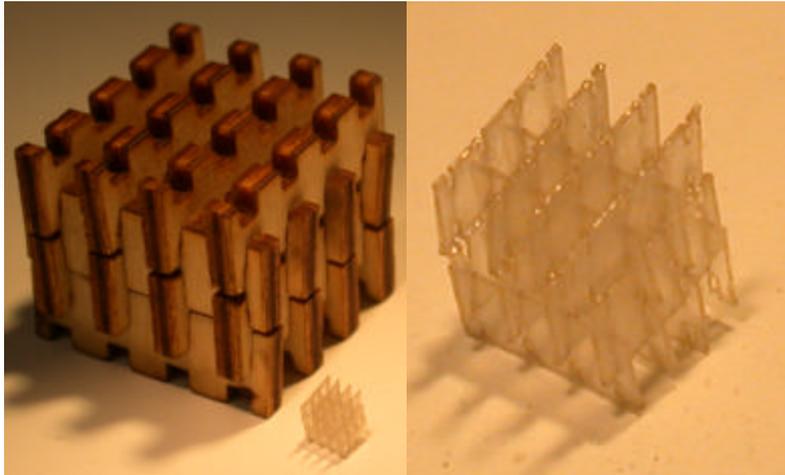
1m



1cm



1 mm



200 μ m



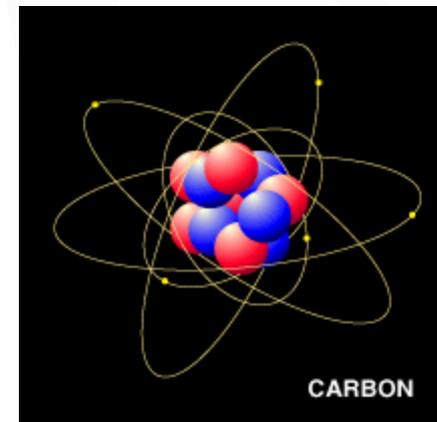
1 μ m (below eye resolution), between atoms and macroscopic

Microscopic vs Macroscopic

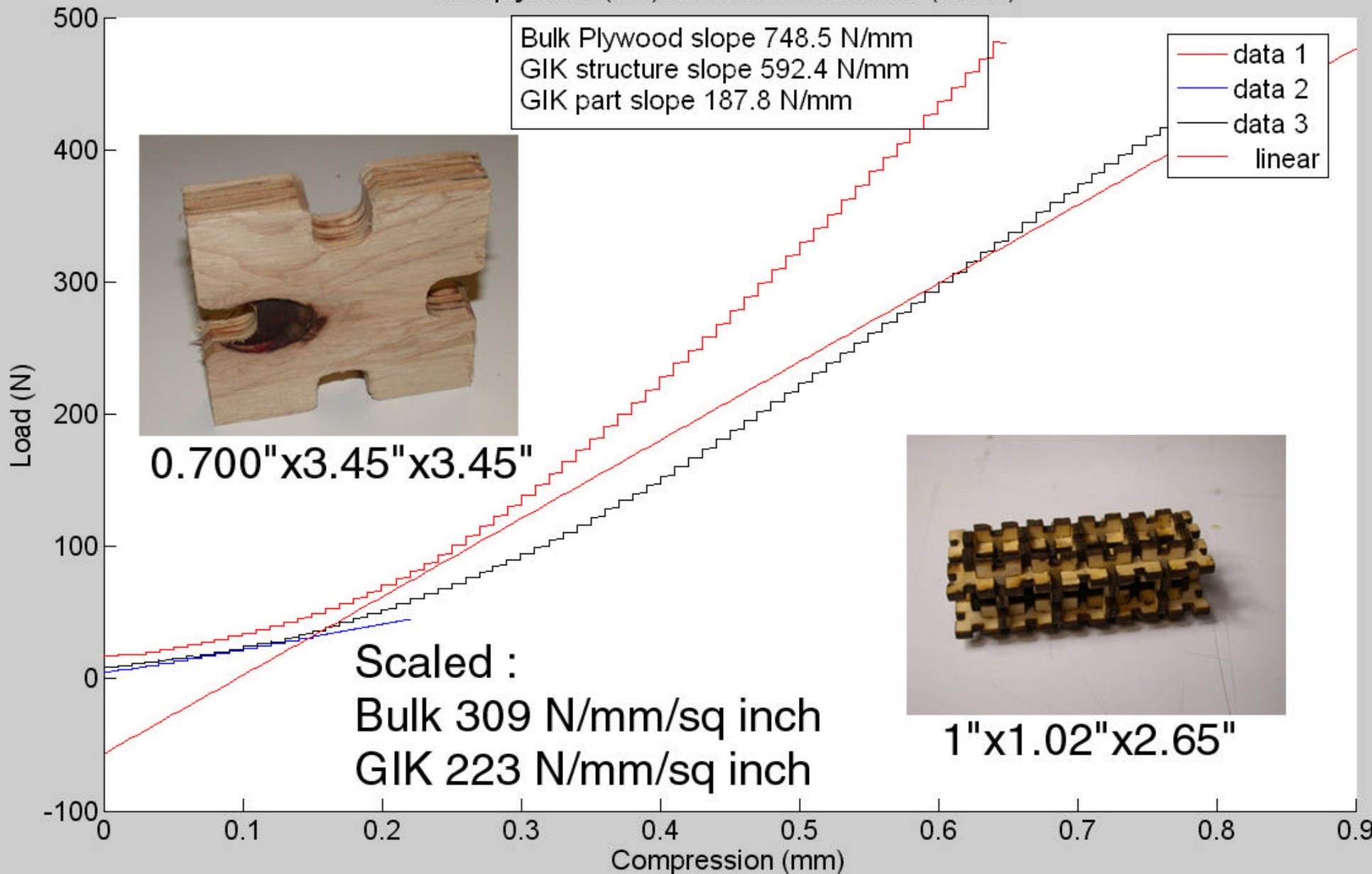
- Compression
- **Tension**
- Stress pattern
- Fatigue
- **Error Reduction**



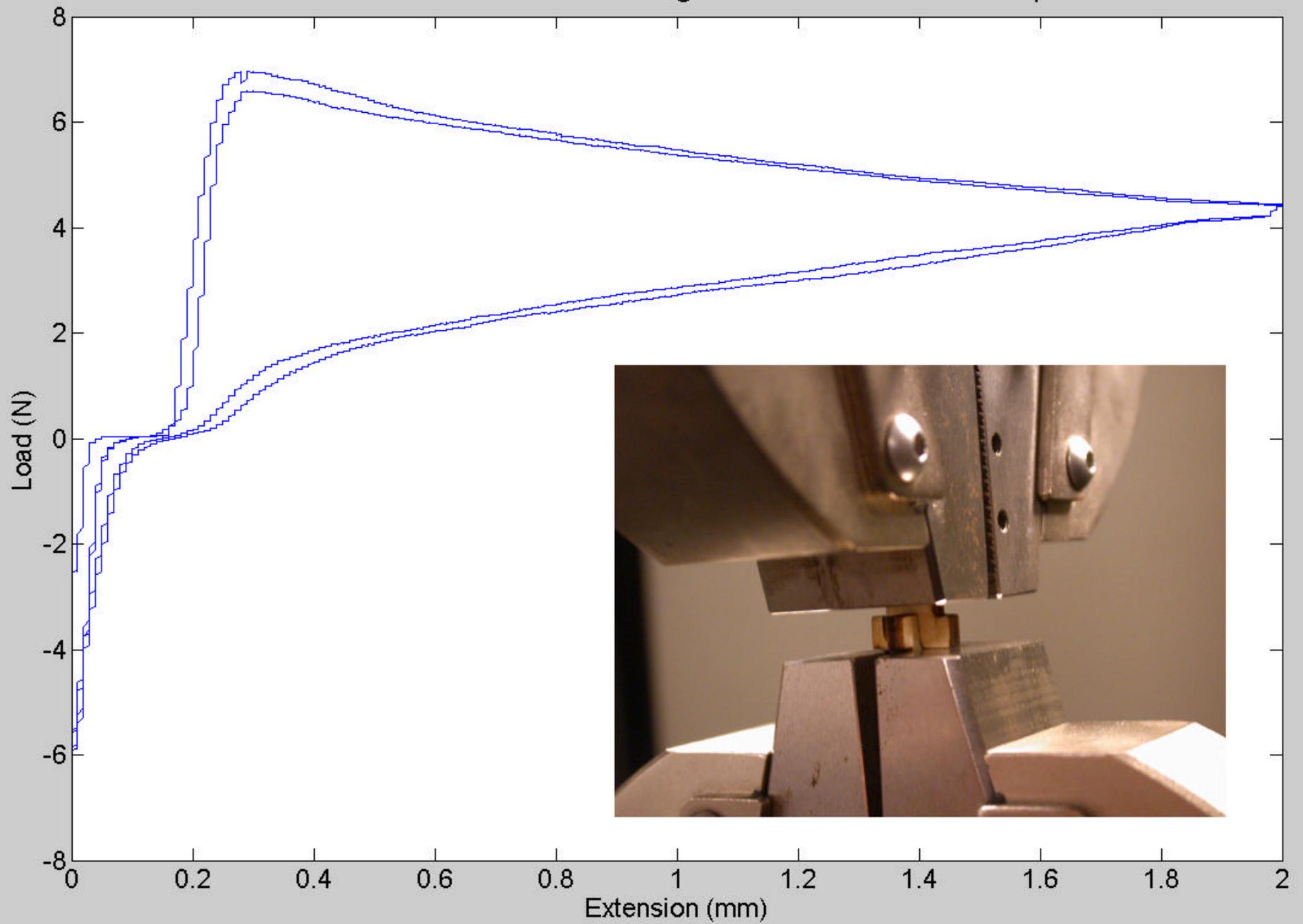
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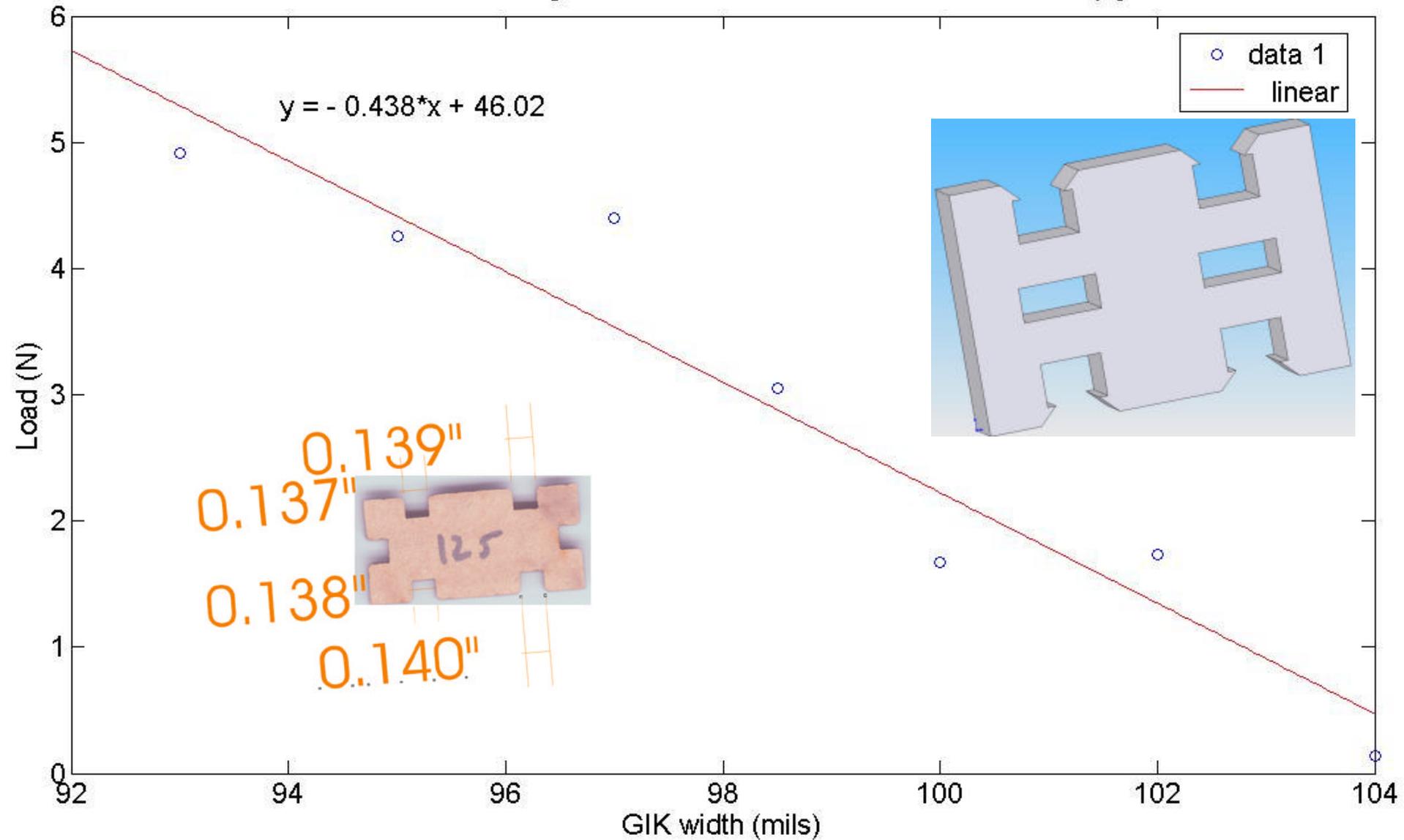
Load compression diagramme for 1 gik part (blue),
bulk plywood (red) and 3D GIK structure (black).



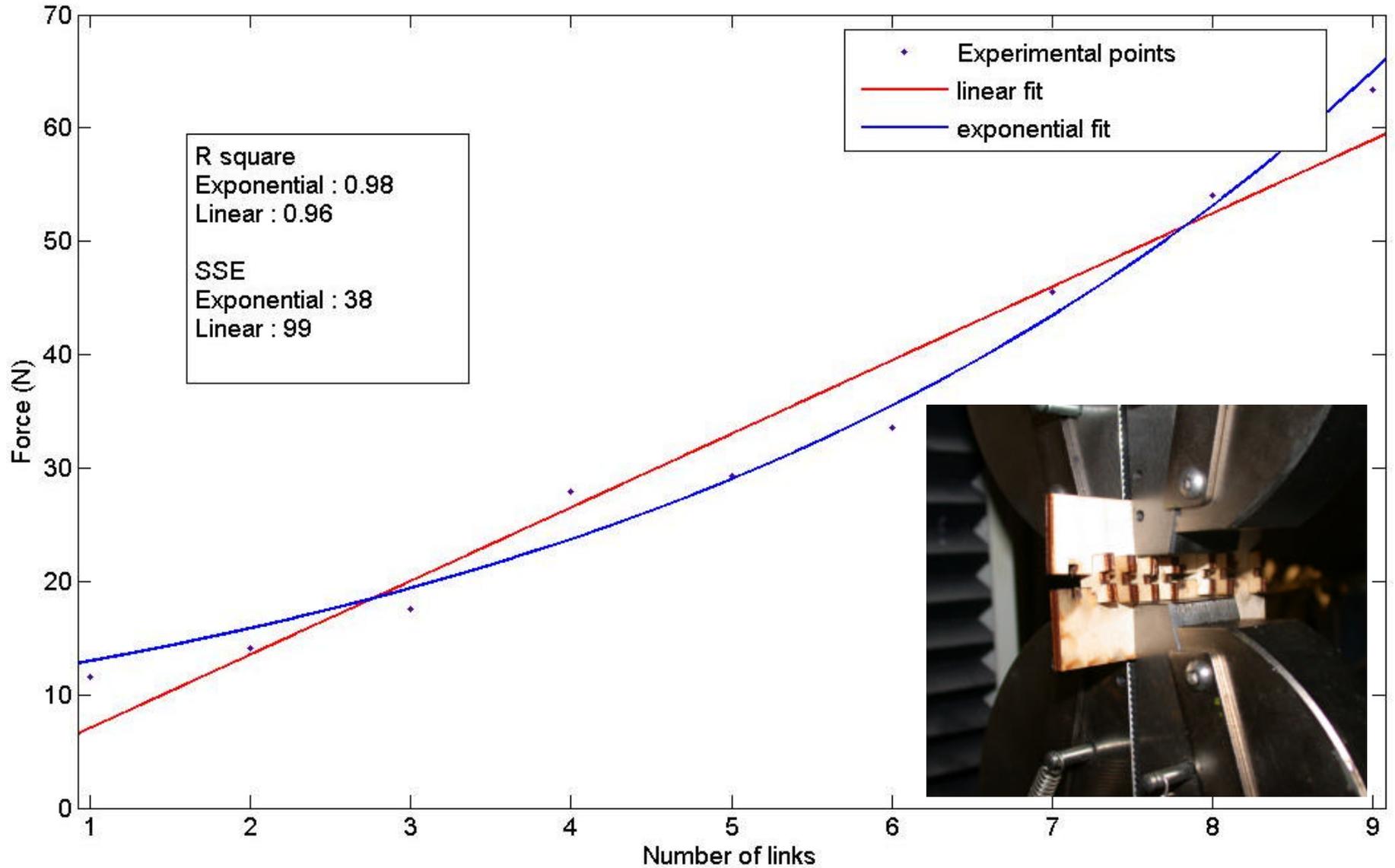
Load Extension curve for assembling two 95 mils White Birch GIK parts



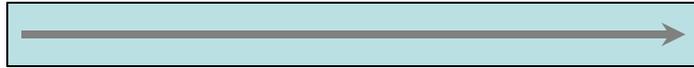
Max load before breaking as a function of GIK width in White Birch plywood



Tension



Causes of Friction

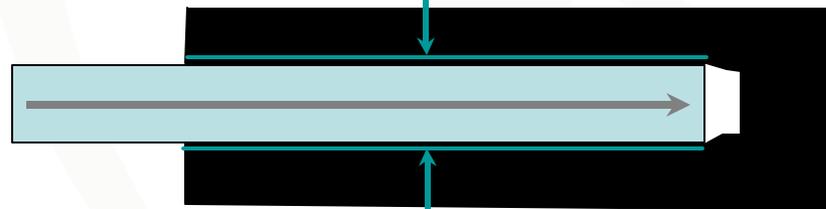


Normal reaction
due to beam
bending :
 F_{nb}



F_{NB}
 F_{NB}

Normal reaction due
to beam
compression:
 F_{nc}



F_{NC}
 F_{NC}

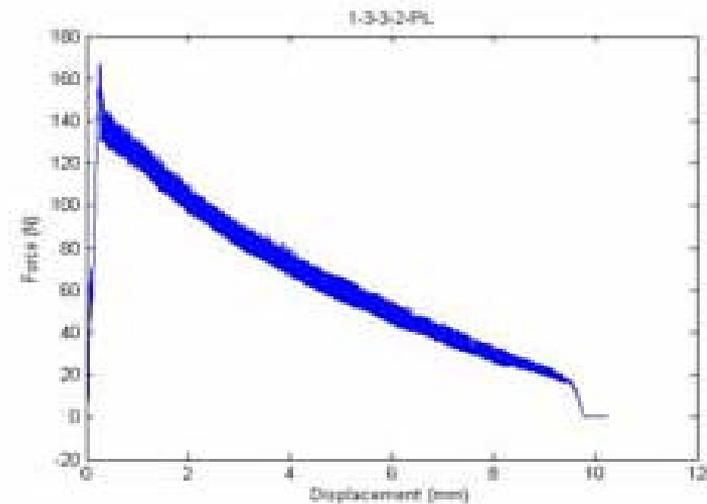
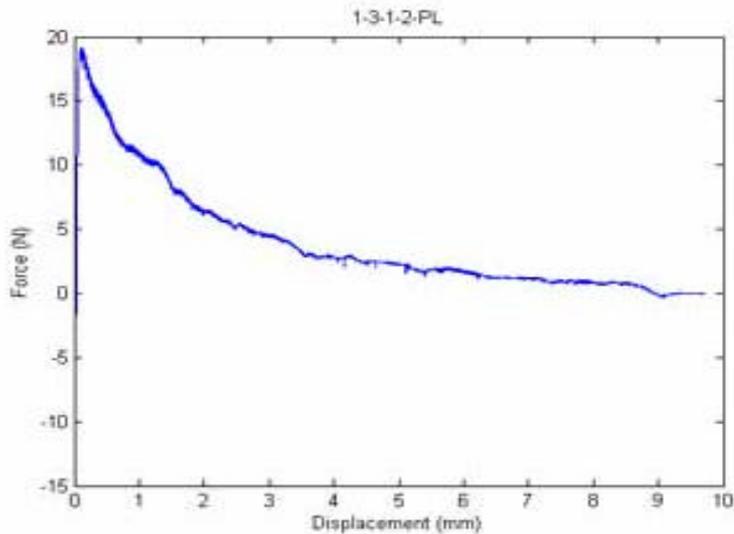
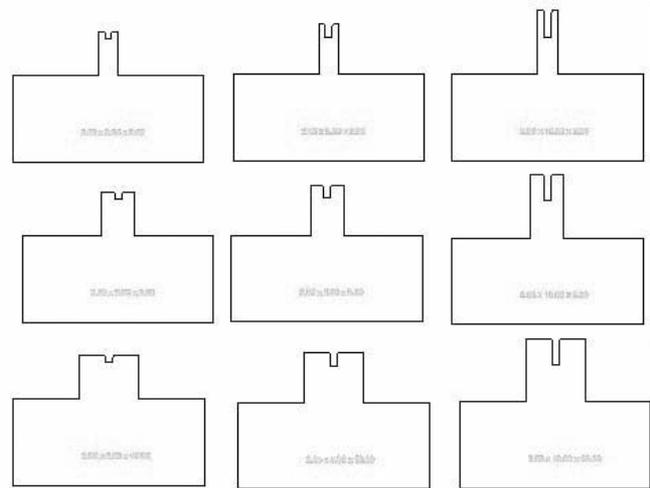
$$F_n = p \cdot F_{nb} + (1-p) \cdot F_{nc}$$

$$F_c = \mu F_n$$

TUSHAR MAHALE

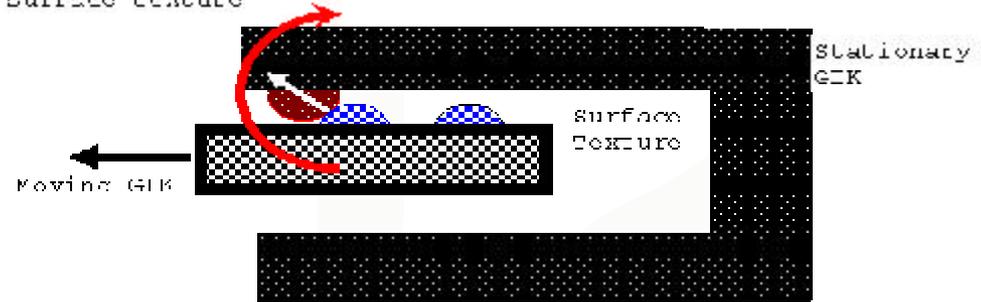
Dept. of Industrial Engineering: NC State University

GJK joint variants & Pull test

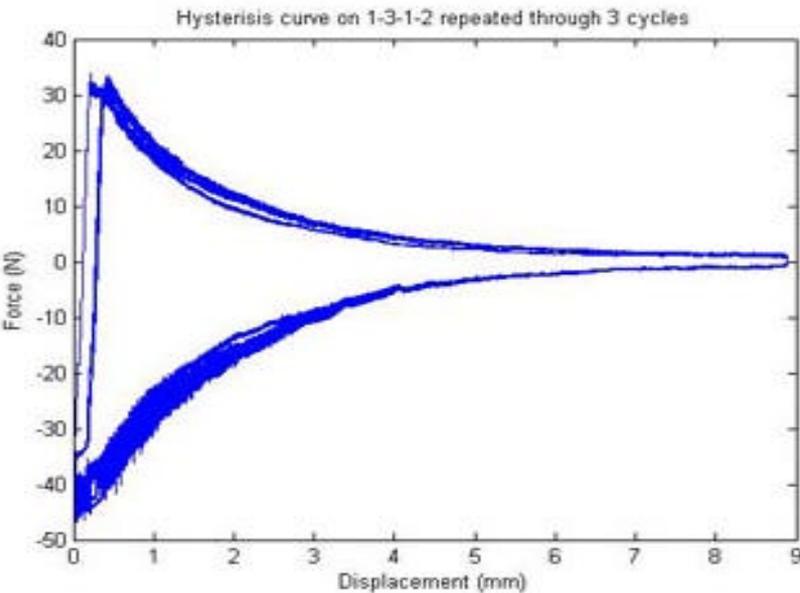
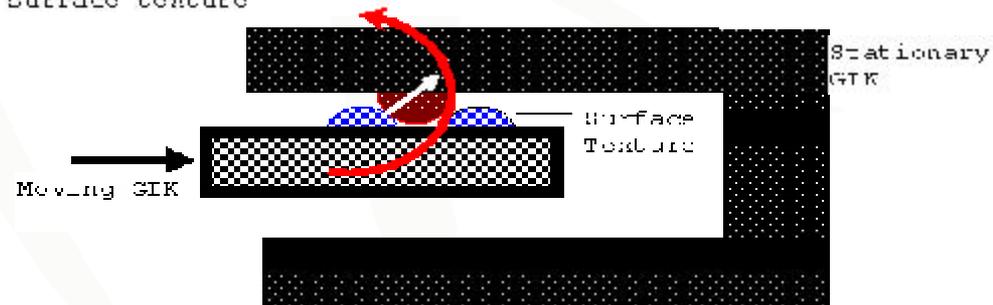


Hysteresis

Reaction & moment caused due to interaction between GIK surface texture



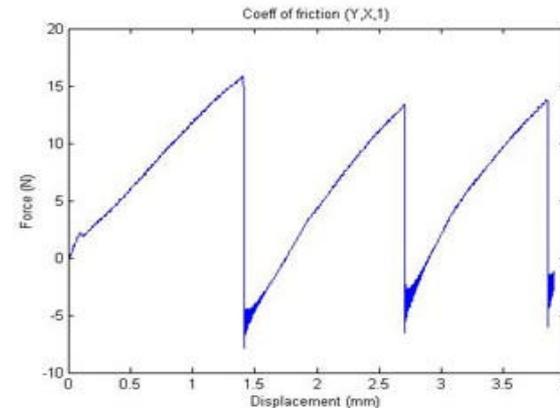
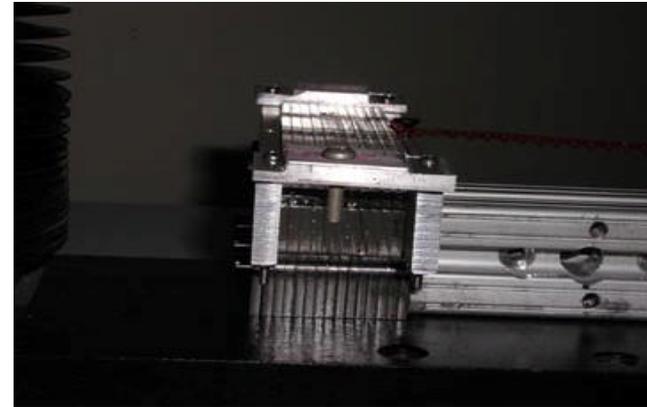
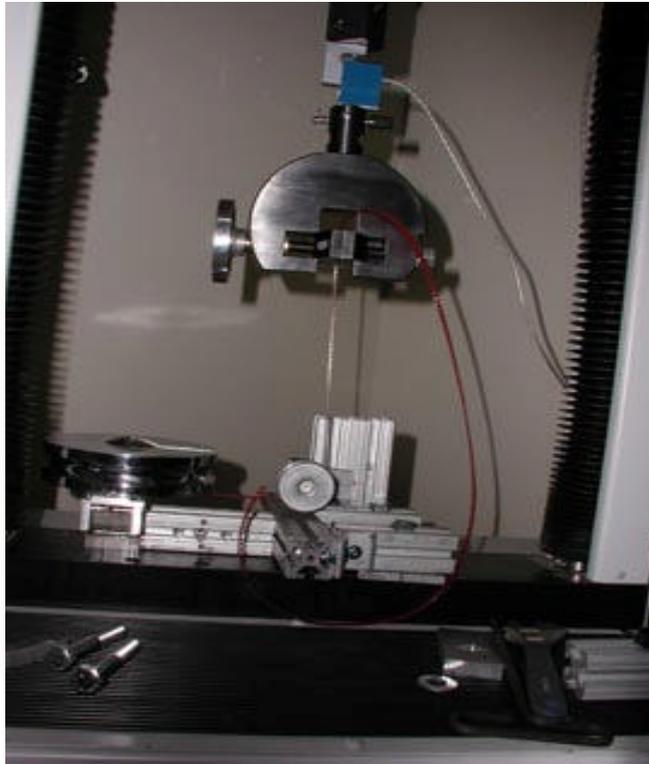
Reaction & moment caused due to interaction between GIK surface texture



TUSHAR MAHALE

Dept. of Industrial Engineering: NC State University

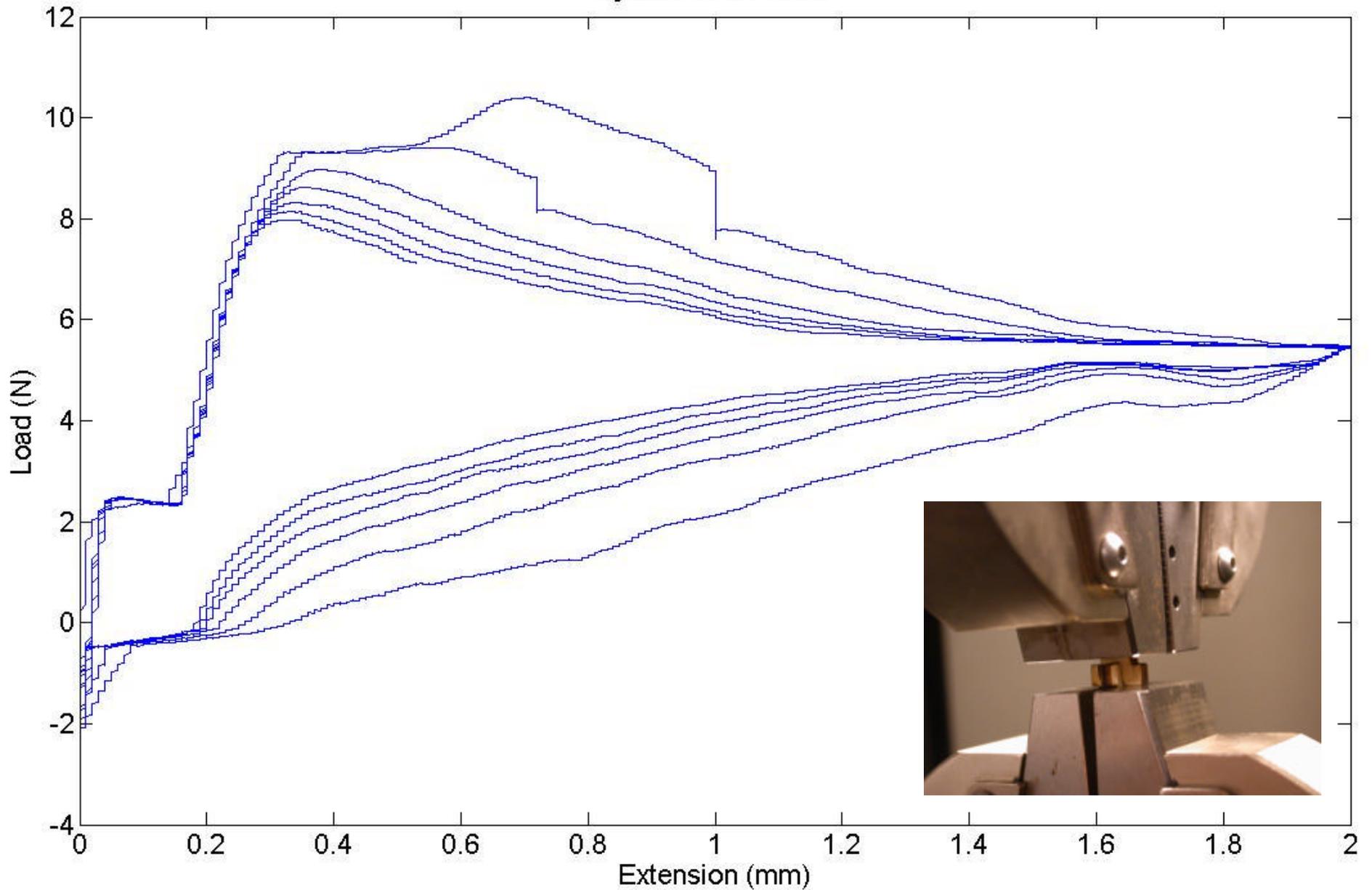
Coefficient of friction



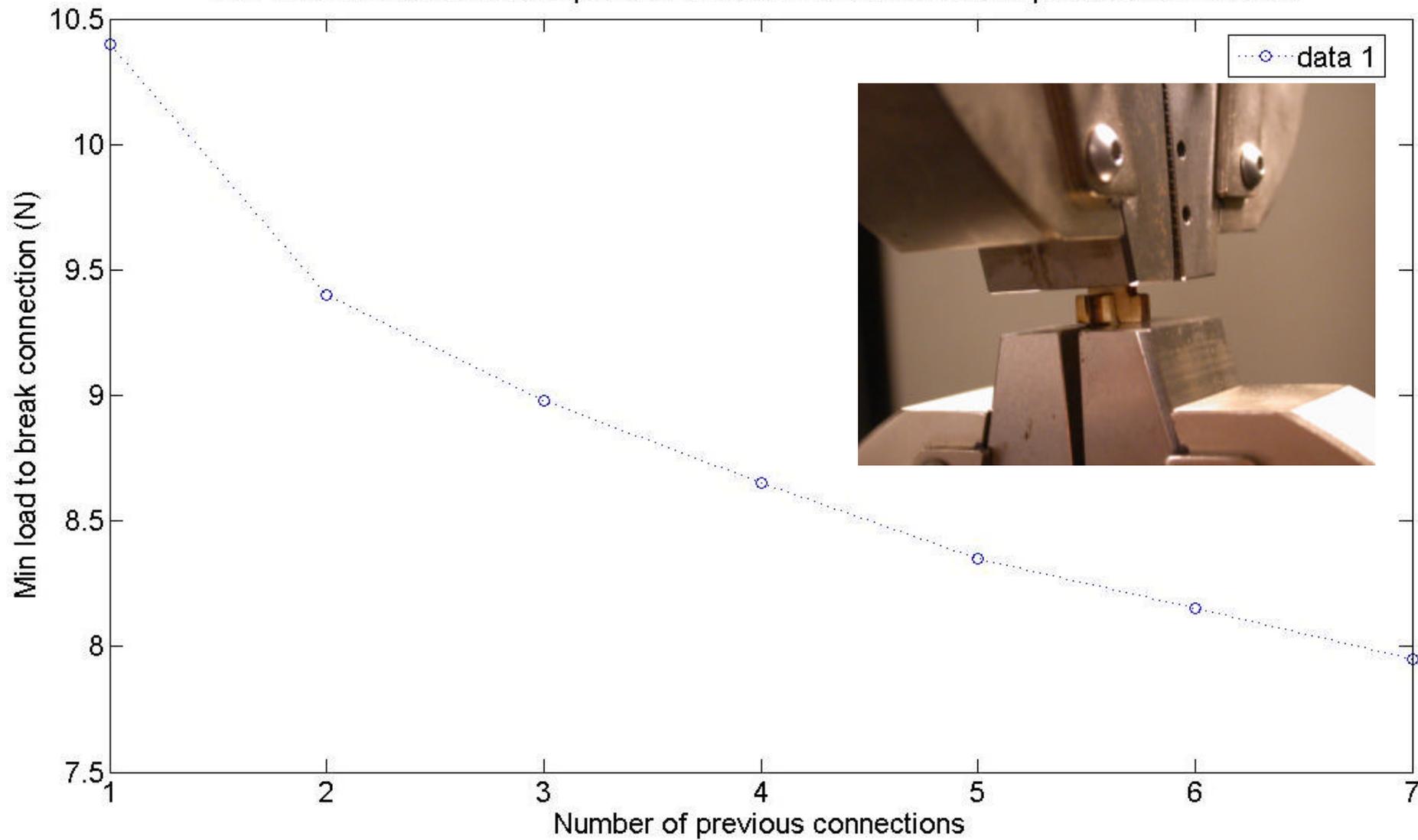
Normal load of 44.5N
 $\mu=0.337$

$$F_n = p \cdot F_{nb} + (1-p) \cdot F_{nc}$$
$$F_c = \mu F_n$$

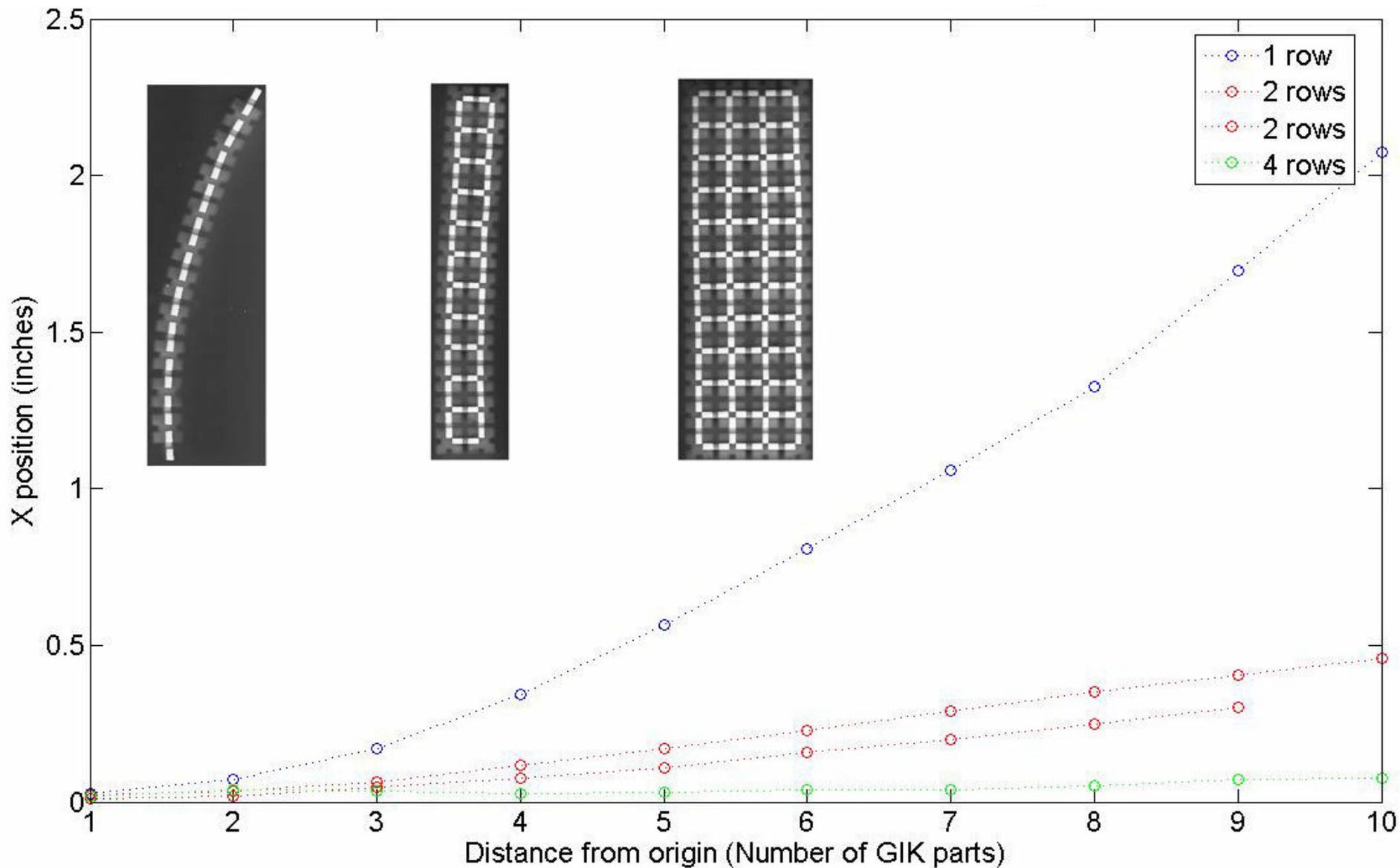
Hysteresis cycle for GIK connection (width 93 mils, white birch plywood)
Cycle ran clockwise



Min Load to disconnect two parts as a function of the number of previous connections

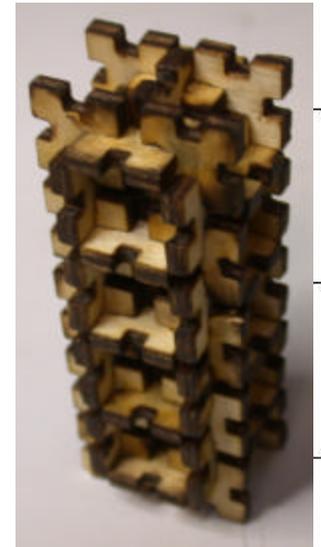
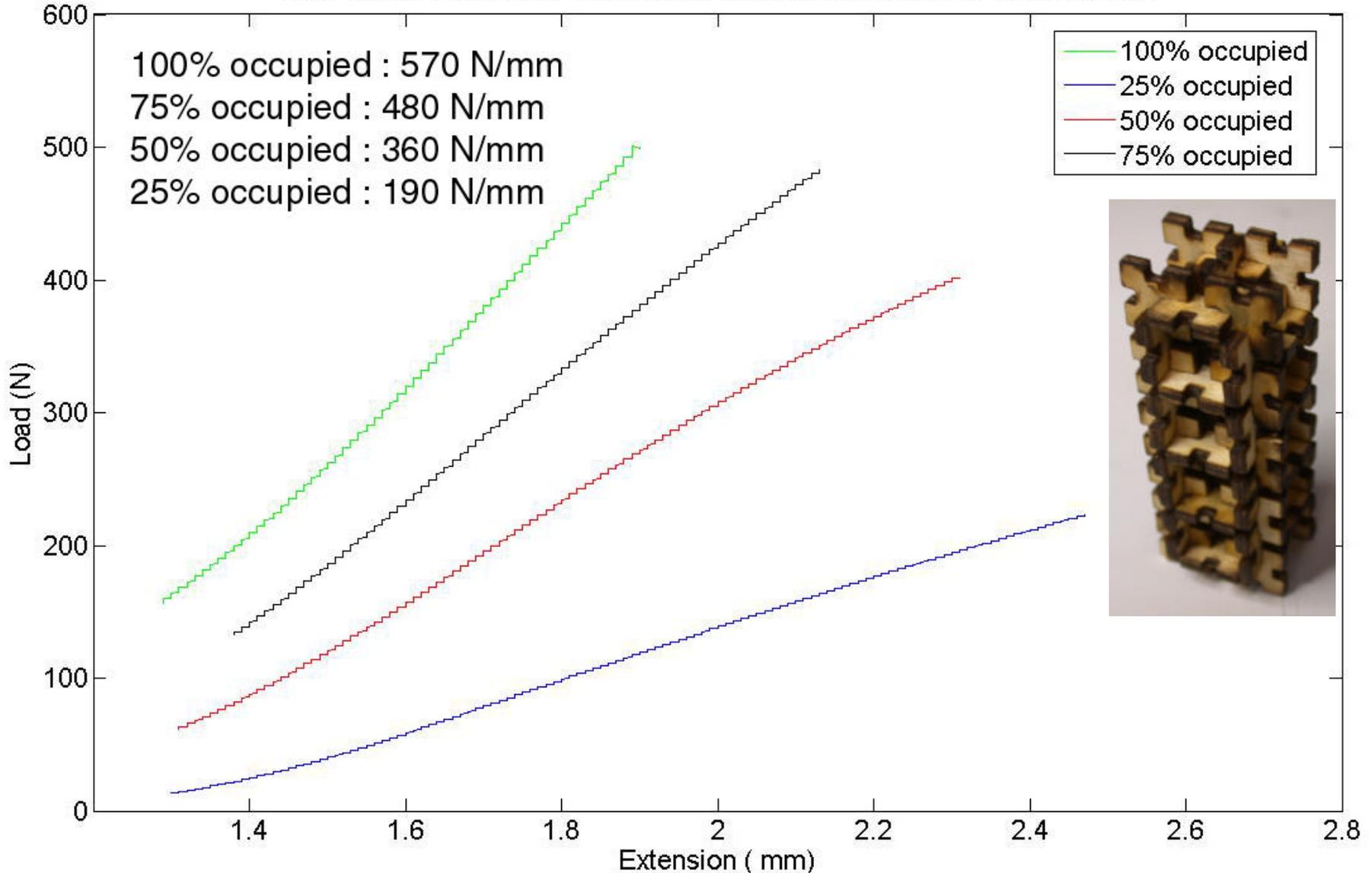


Error Reduction



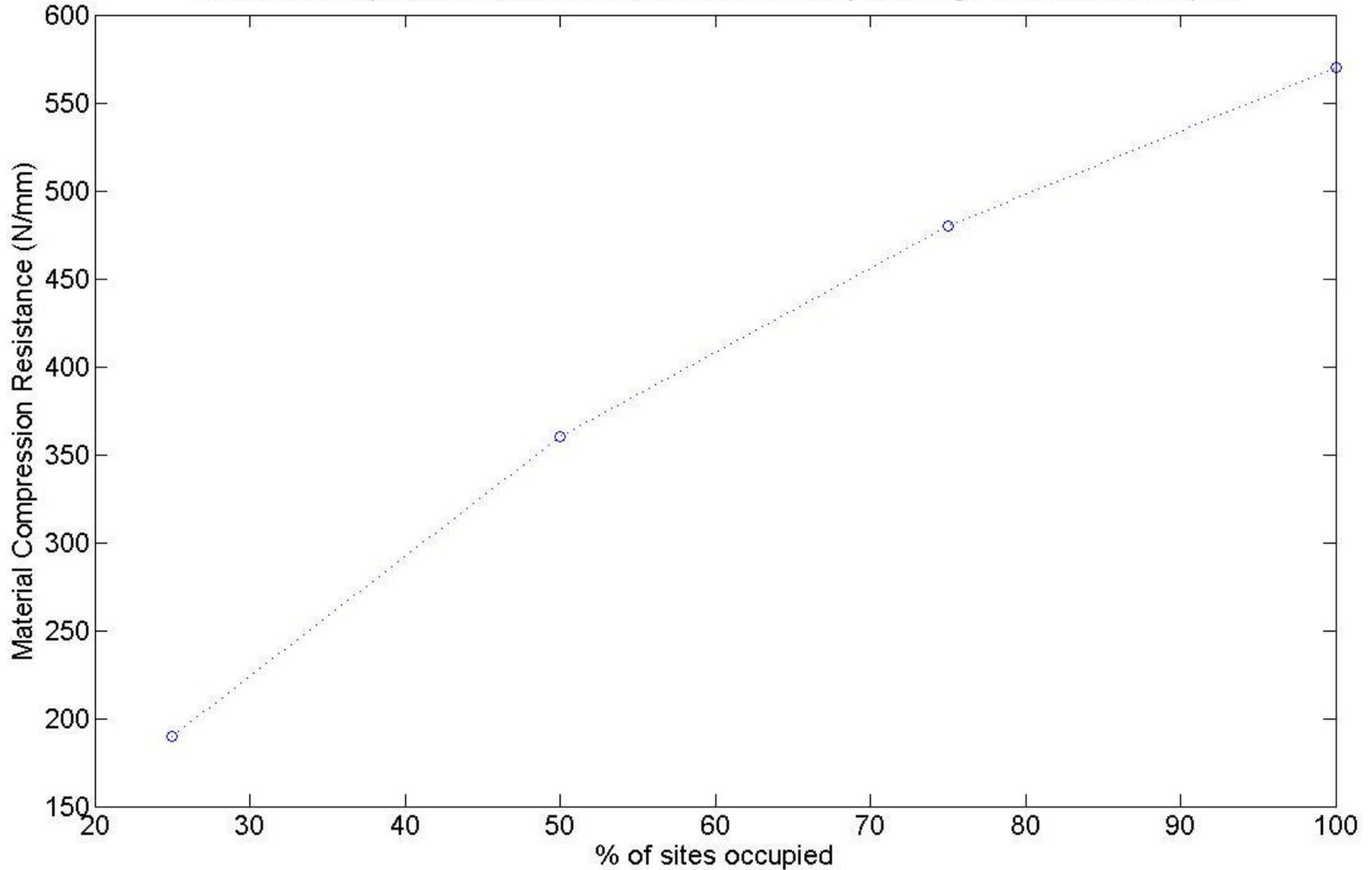
Bonus : Material Tuning

Load extension diagram for material tuning using Delrin 117 mils slot size



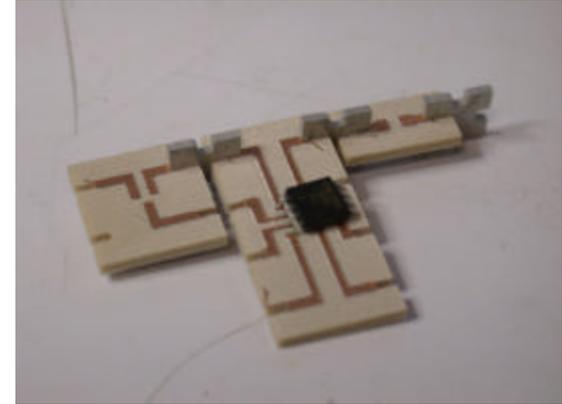
Material Tuning

Delrin GIK compression resistance as a function of the percentage of link sites occupied



Active Materials

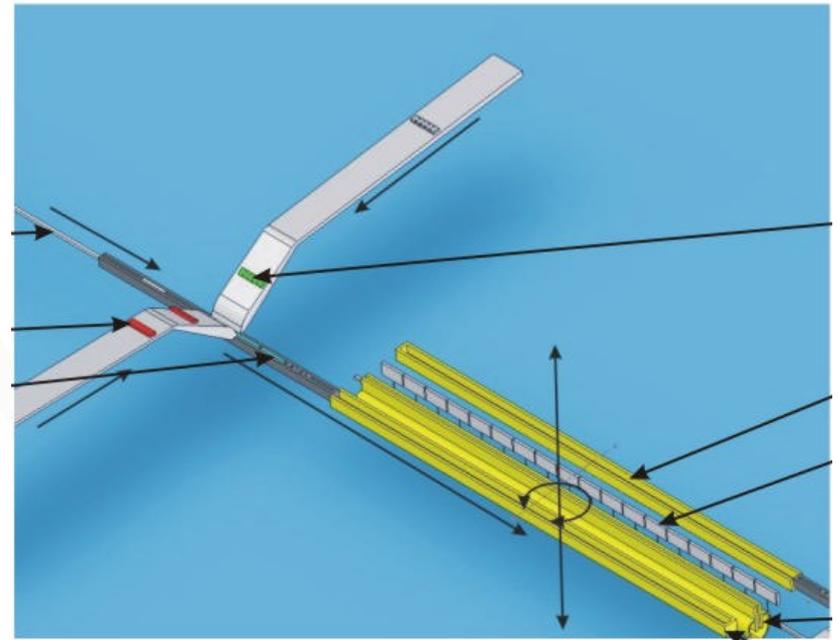
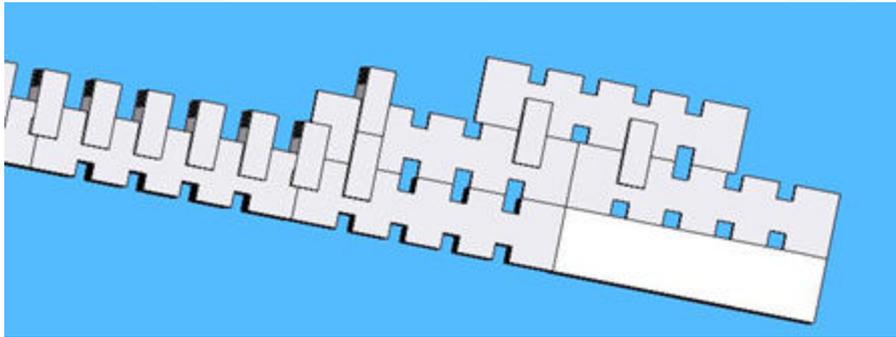
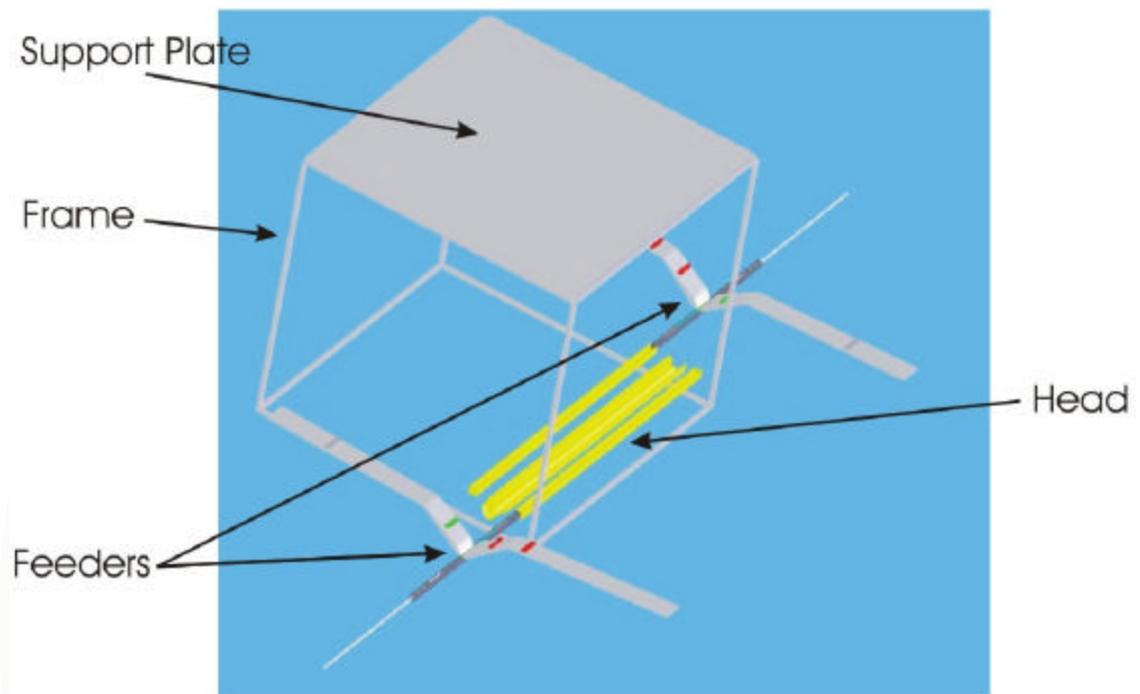
Conducting, insulating : Electronics ? PCBs ?
Transparent, opaque : Optics ?
Different refractive index : Photonic Crystals?
Soft, hard : Joints ?
Conducting, Semiconducting : Transistors ?

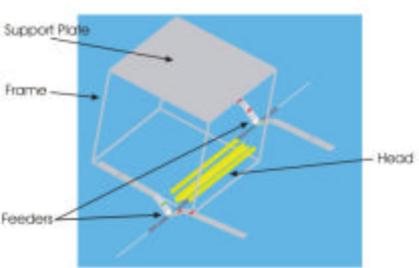


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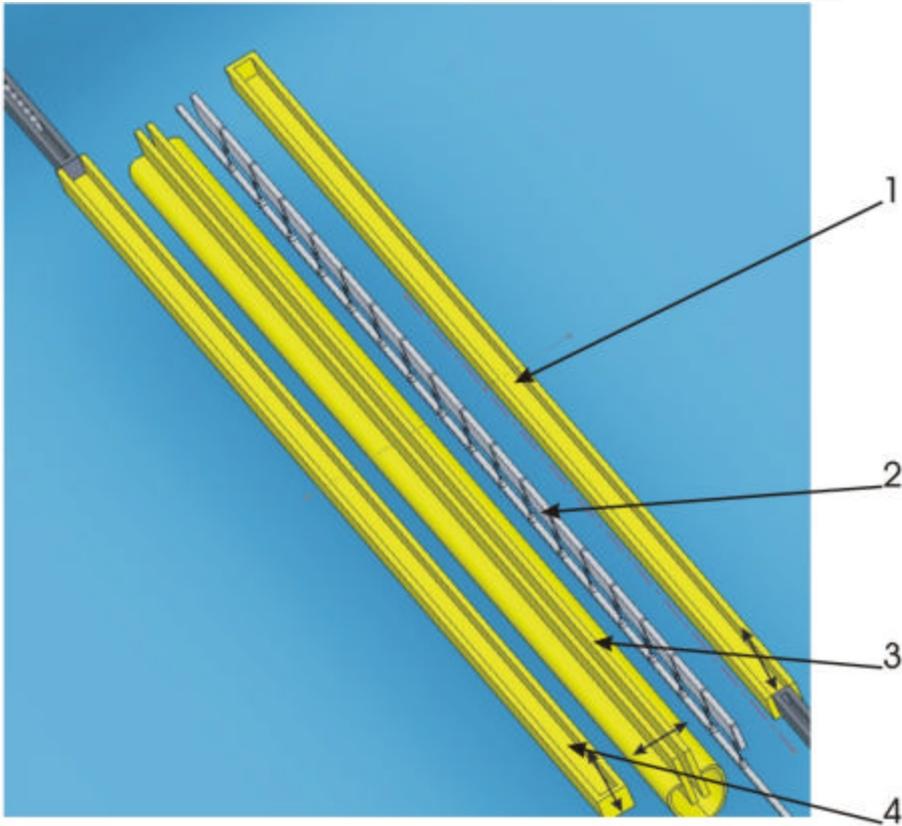
?

GIK Assembler





The head



Blade 1 is building
Blade 2 is detecting errors
Blade 3 is removing errors
Blade 4 is rebuilding the removed lines