

Microfabricated Wire Arrays for Z



Sandia National Laboratories

Mike Cich, Olga Spahn, Greg Peake, John Klem, Melissa Cavaliere,
Charles Sullivan, Chris Dyck, Dustin Romero, Tom Nash, Mark Kiefer

WIRE ARRAY INTRODUCTION

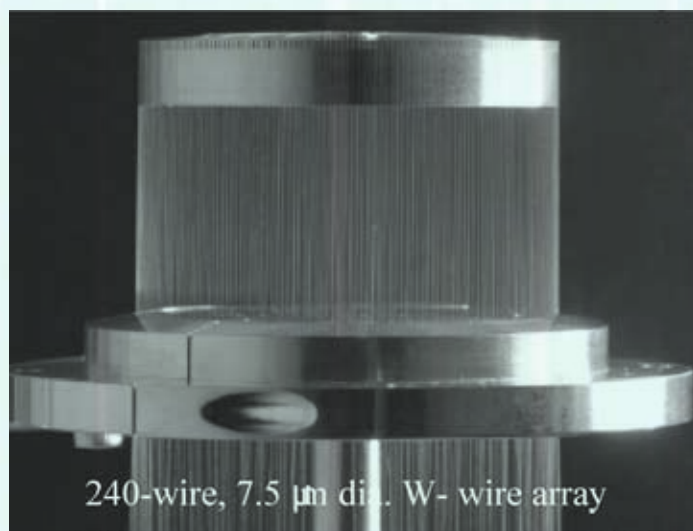
Wire arrays sit at the heart of the Z machine. The Z discharge vaporizes these wires to form a plasma which implodes onto the "Z" axis

- Currently arrays are hand-assembled on precision-machined mandrels
- Use fine (~5-10 micron) wires that are difficult to handle and inspect
- Wire array uniformity may play a crucial role in optimizing the power output from Z

OBJECTIVE

To use planar microfabrication techniques to produce wire array Z-pinch loads allowing:

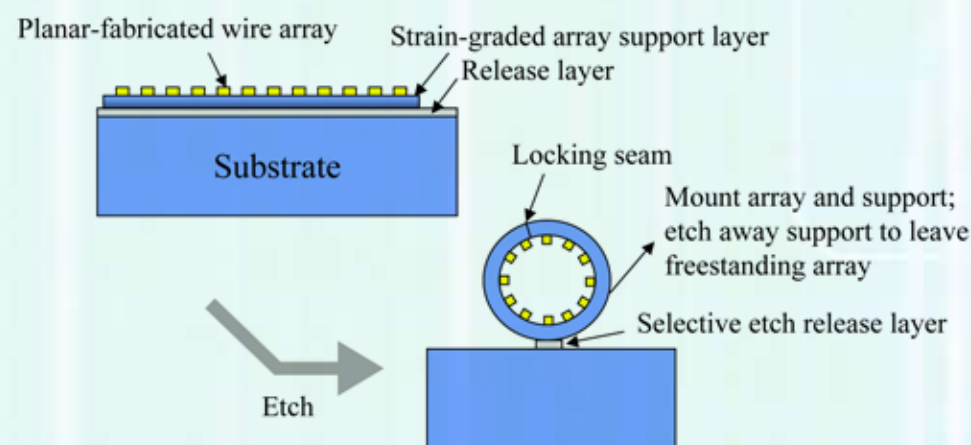
- Flexibility in wire design: axial tailoring of wire shape and composition
- Simplified, highly reproducible wire array production
- Uniform electrical contact to all wires



240-wire, 7.5 μm dia. W-wire array
Spielman et. al., Phys. Plasmas 5, 2105 (1998).

MEMS-INSPIRED FABRICATION APPROACH

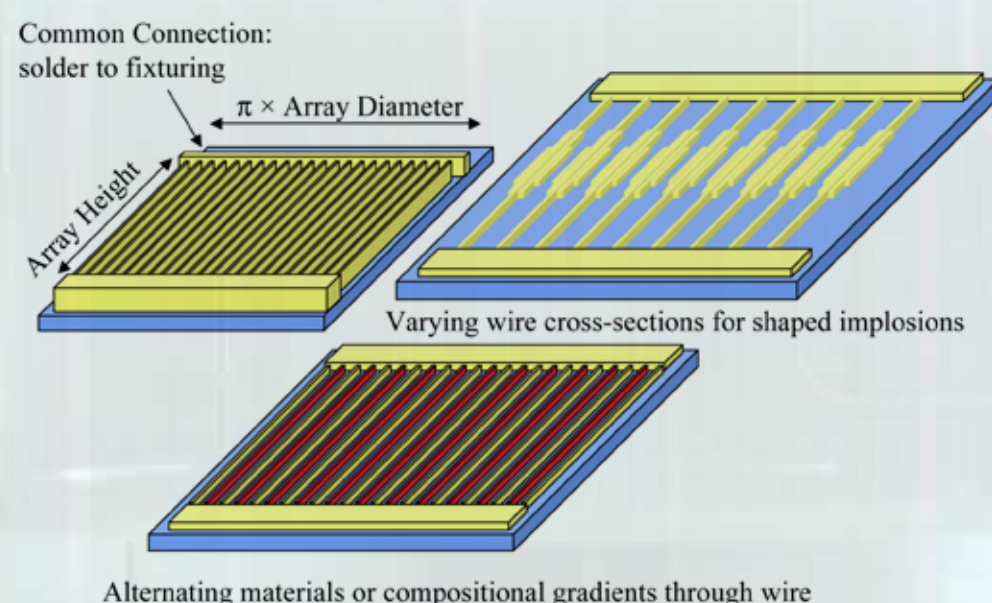
Sacrificial epilayer with graded-composition structural epilayer to introduce controlled strain



Microfabrication method permits novel array structures to be engineered for optimization and focused studies of wire implosion science

DESIGN FLEXIBILITY

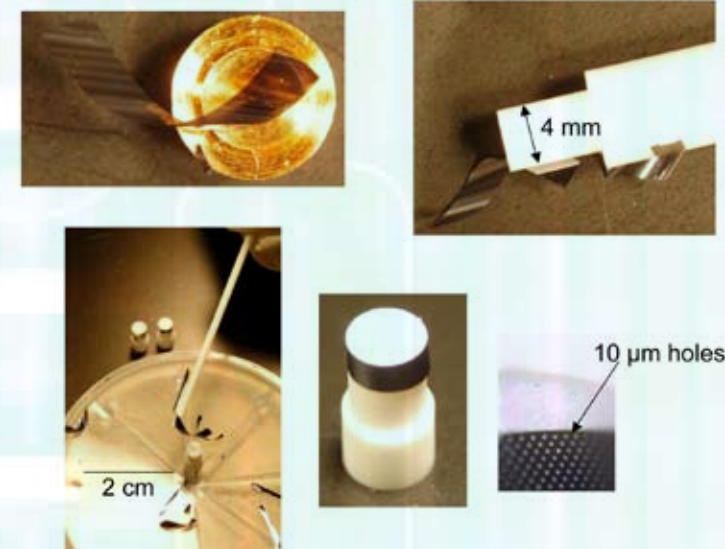
Microfabrication method permits novel array structures to be engineered



SEMICONDUCTOR-SUPPORT RESULTS

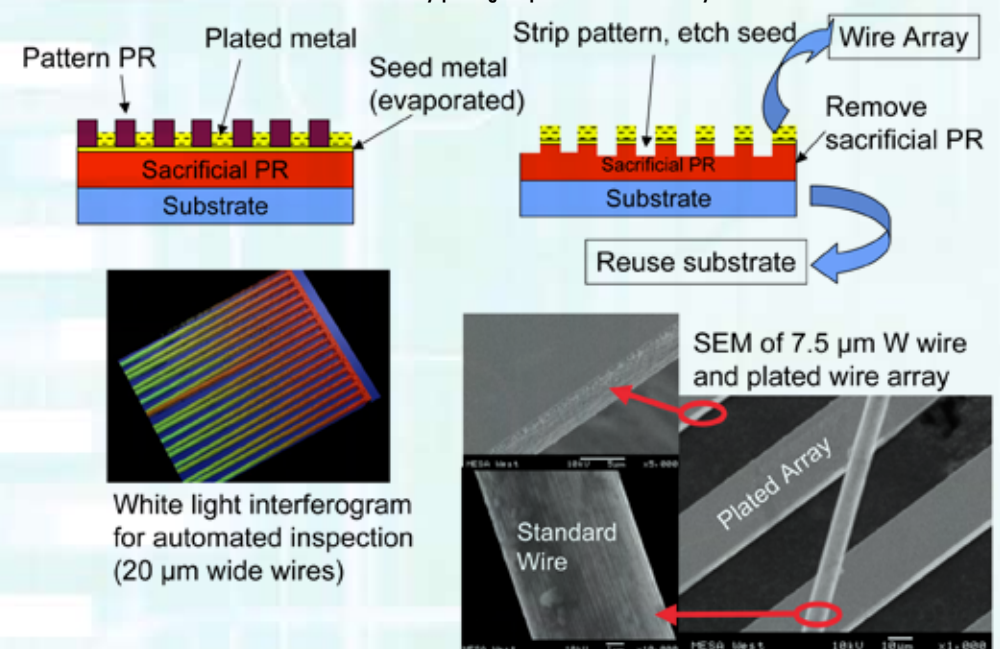
Fabricated and released supports with 4 mm design diameter, with and without release holes

- Mounted on copper, macor, and polyethylene 4mm mandrels
- Electrostatic and surface tension handling techniques
- Spiral as-released shape easy to handle, conforms to mandrel shape on liquid application



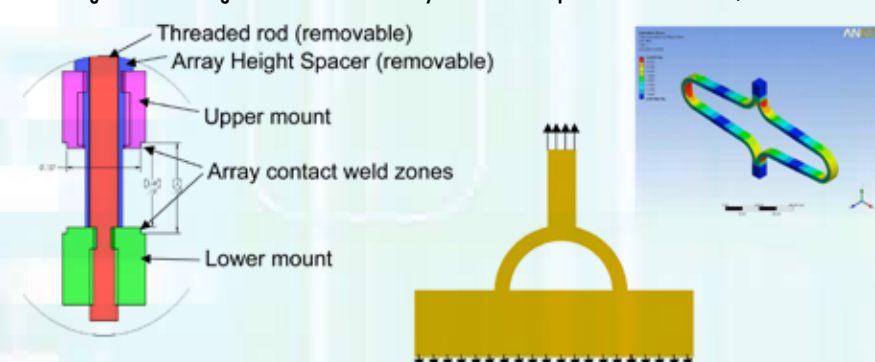
EPI-FREE WIRE ARRAY RESULTS

Process for wire array plating on photoresist release layer



ARRAY MOUNTING RESULTS

Mounting hardware designed and fabricated Arrays will be laser spot-welded to cathode/anode connections



Solid contact approach

We will fabricate flexible wire connections able to accommodate displacements during array loading in Z
Relief designs are being modeled and optimized using ANSYS

SUMMARY AND SIGNIFICANCE

- We have fabricated proof-of-concept 4-mm diameter gold wire arrays using two methods:
 - Strained semiconductor foil supports
 - Epi-free no-support plated arrays
- We will demonstrate 20-mm diameter platinum arrays in 2008
 - These will be usable in Z for direct comparison to manually-assembled platinum wire arrays
- Once optimized, we expect:
 - Simpler, better-controlled fabrication and assembly
 - More materials and design flexibility, including non-cylindrical structures
- Microfabricated wire arrays will open up a new area of array design and optimization for Z-pinch plasma physics experiments



Sandia National Laboratories