Low-Cost MEMS Initiators

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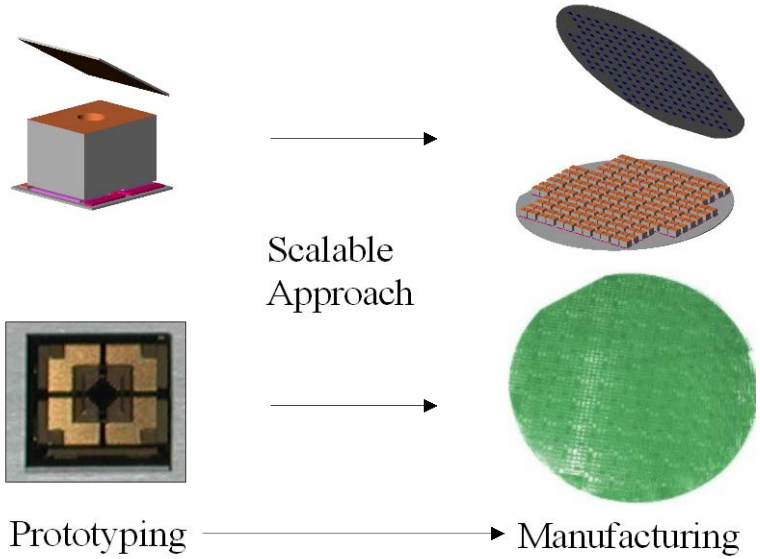
MEMS Background

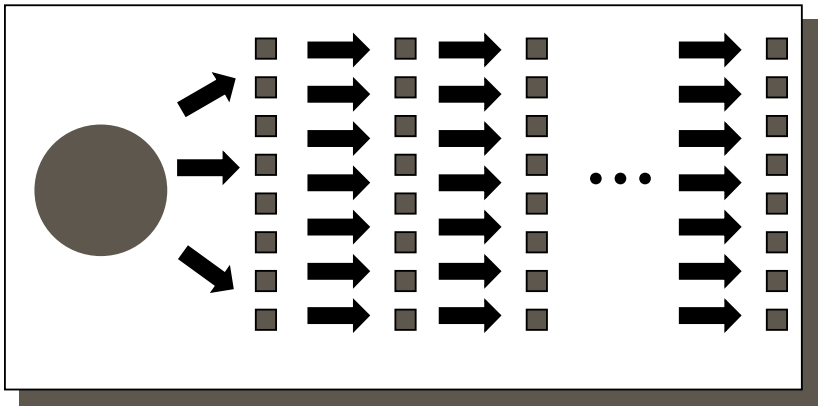
- Applications beyond Munitions
  - Airbag initiators
  - Stability Control
  - Televisions
- Benefits using MEMS
  - Low cost
  - Reliability
  - More intelligent systems
  - Scalability



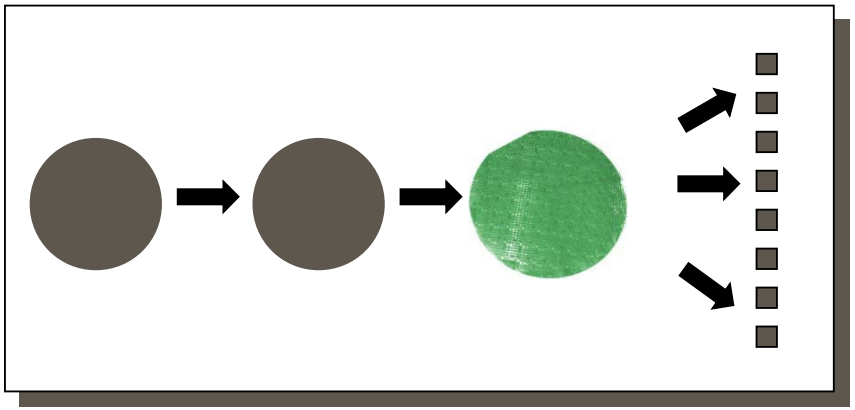
Batch Assembly

- Assembly/Packaging is Expensive
  - Each Part Must Undergo Many Steps
- Unique Capability
  - One Hundred Steps vs. Tens of Thousands
  - Reduce Cost by >10X

Conventional One-at-a-Time



Our Solution: Thousands-at-a Time

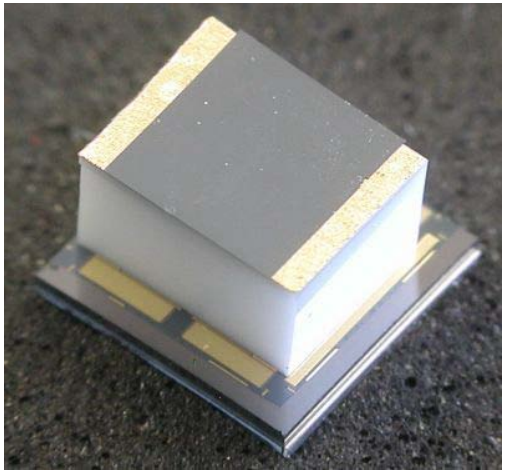


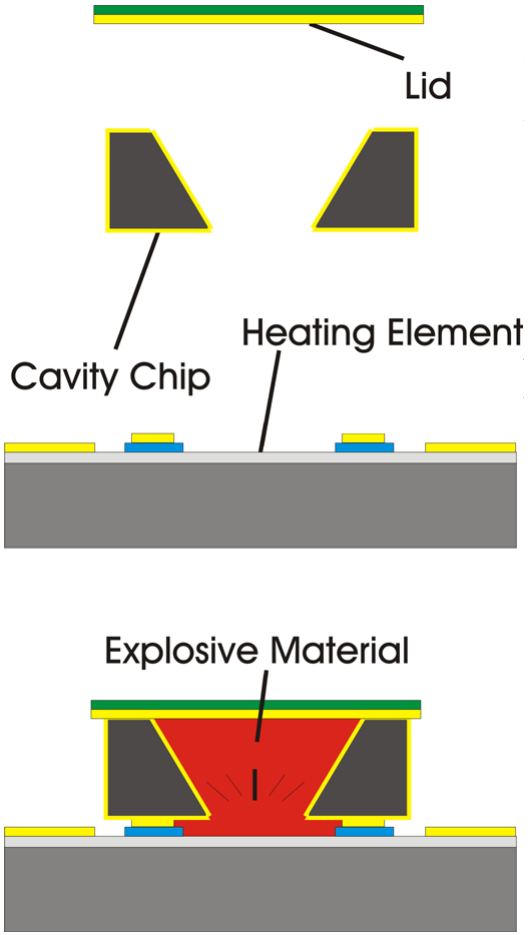
MEMS Initiators

- M100 Drop-In Replacement
  - Batch Processing = Lower Cost, Higher Reliability
  - Commercial Applications
    - Mining, Construction, Oil Drilling
- Silicon Bridge Initiator
  - For Navy IHDIV S&A devices
  - Applications
    - 40 MM Grenades
    - Mine Countermeasure Dart

Initiators for M100 Replacement

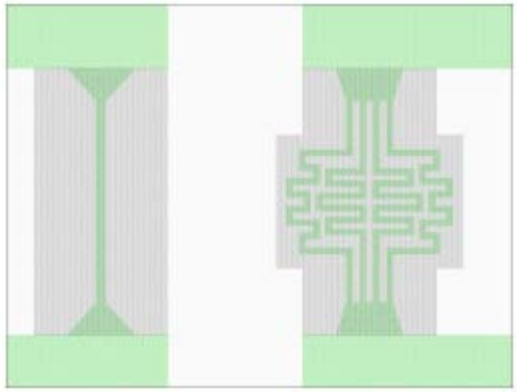
- Three Layer Design
- Tungsten Heating Element
- Batch Processes
  - Fabrication
  - Loading
  - Packaging



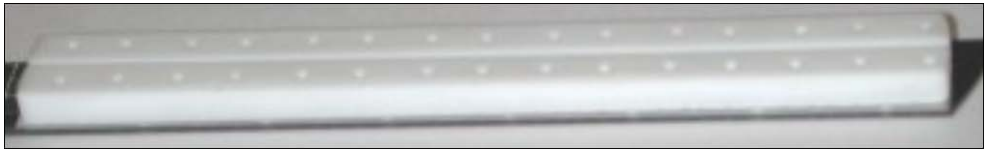


1st Generation M100 Replacement

- Pyrex Substrate
- Tungsten Bridgewire
- Fired at 3V off 100µF cap
- Pyrex Substrates Pose Process Issues



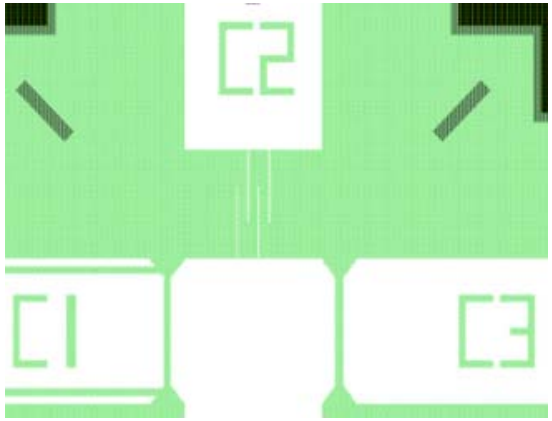
Heater Devices

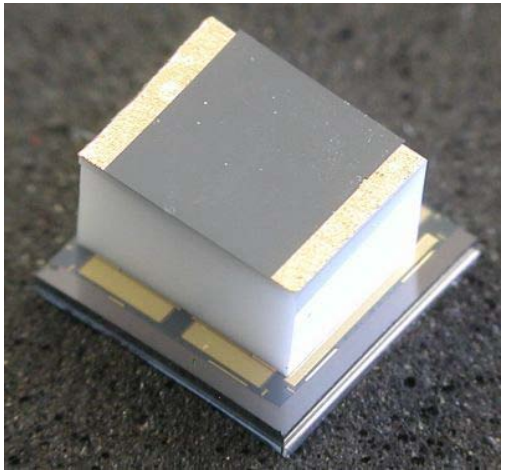


Microdetonator Devices

2nd Generation M100 Replacement

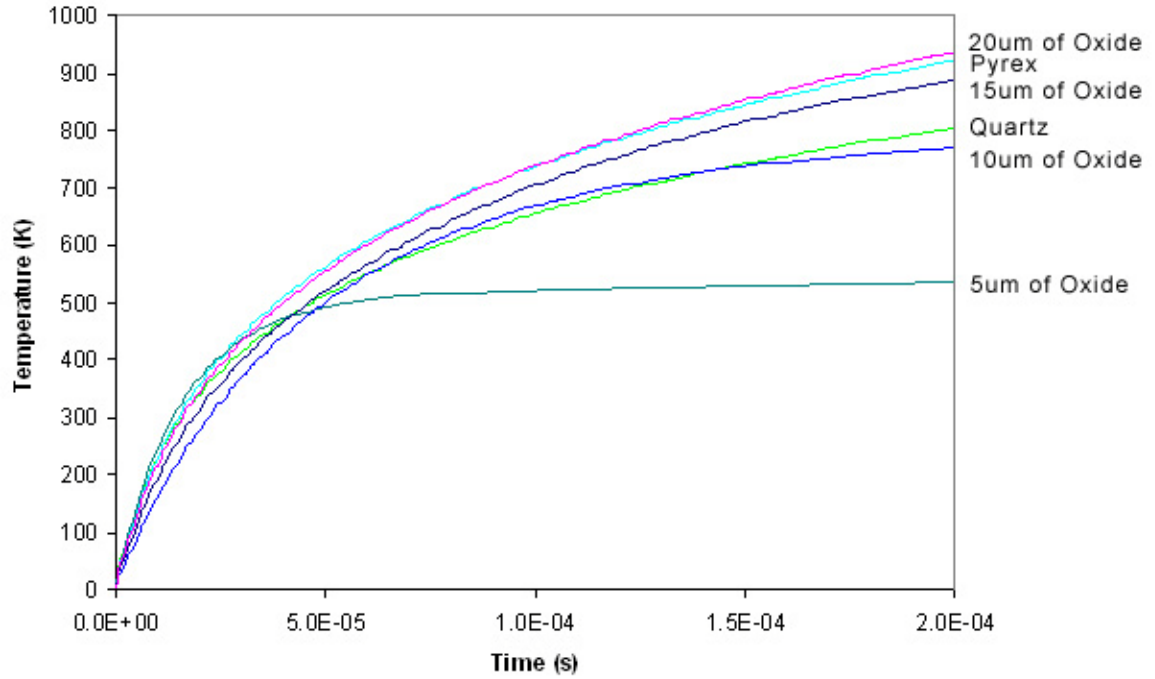
- Pyrex Substrates and Silicon Substrates
- Devices on Pyrex Substrate fired at 3V
- Devices on Silicon Substrate fired at 5V (thermal loss)





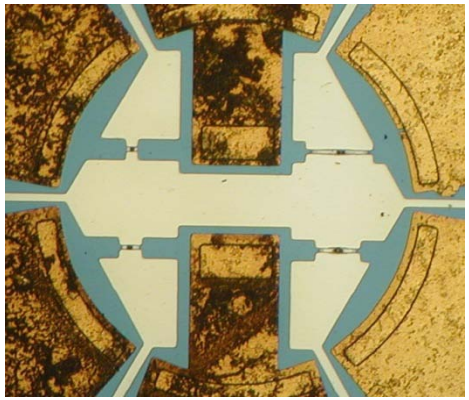
Heater Substrate Modeling

- Silicon with thick oxide layer possible
- Long CVD process is not ideal
- Quartz substrate more cost effective



3rd Generation M100 Replacement

- Quartz Substrate
- Lower parasitic resistances
- Higher energy dissipation over bridgewire
- Neyer Test on 3rd generation devices
  - 23 devices tested
  - μ=1.6088 V σ=0.0966 V
  - All-fire at 2.0 V
  - No-fire at 1.2 V

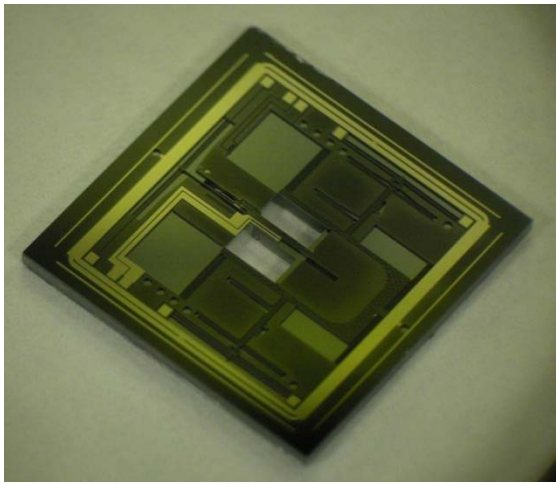


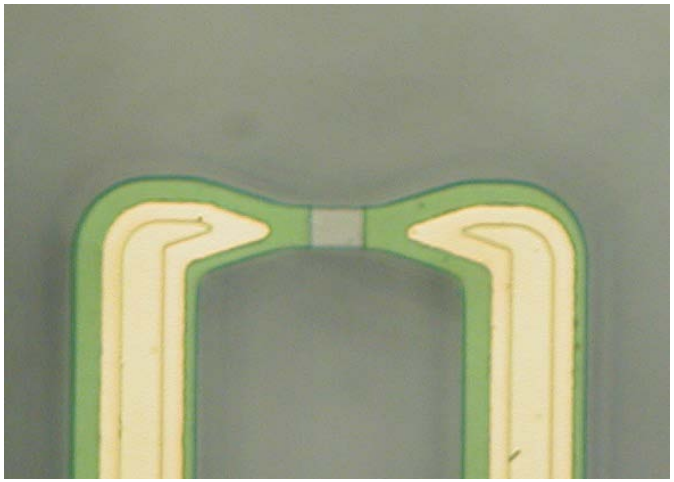
4th Generation M100 Replacement

- Lower parasitic resistances
- Higher energy dissipation over bridgewire
- Neyer Test on 4th generation devices
  - 30 devices tested
  - μ=1.2097 V σ=0.0220 V
  - All-fire at 1.6 V
  - No-fire at 0.7 V
  - Dent into Aluminum: 0.020”

Initiators for S&A Device

- Navy IHDIV S&A devices
- SOI MEMS Process for Safe & Arm Device
- Silicon Semiconductor Bridge (SCB) Initiator
- Integrated Initiators Fabricated in Batch Semiconductor Processes

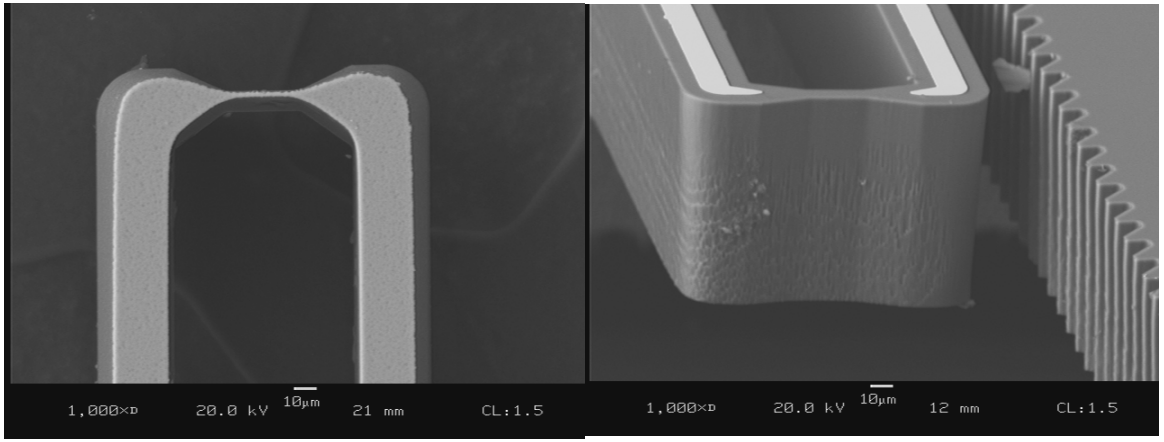




NSWC Silicon Bridge Initiator

- Composed of a silicon bridge
- Unique geometry used for MEMS S&A device (bridge volume ~ 20,000 μm^3, dimensions in the 10's of µm)
- Bursts and forms plasma when voltage is applied
- Plasma crosses air gap (2-5 µm) to initiate primary explosive

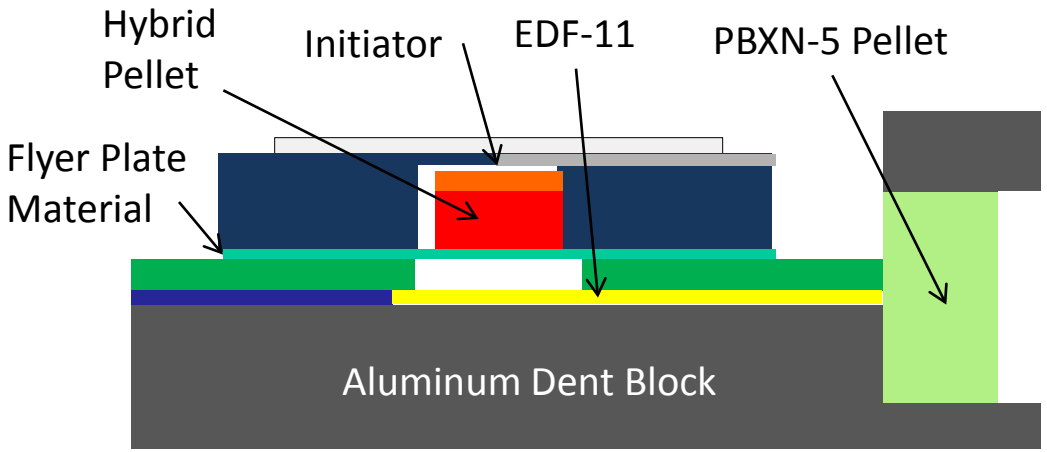
NAVSEA
WARFARE CENTERS
INDIAN HEAD



Silicon Bridge Test Setup

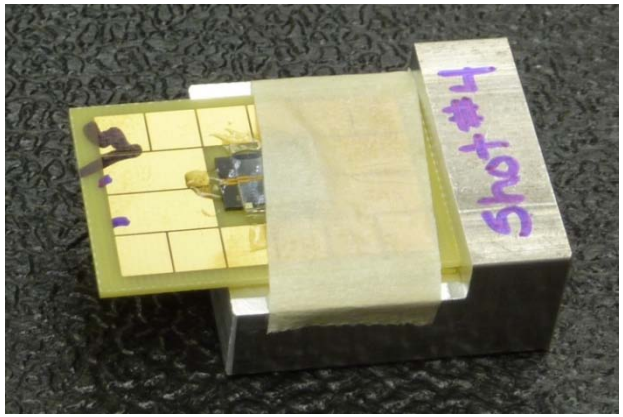
- Navy IHDIV devices
- Explosive train feasibility study with various geometries tested
- Plasma initiates lead styphnate/silver azide pellet
- Sending metal flyer into and initiating EDF-11 strip (12-40 mils thick)
- EDF-11 charge transfers to PBXN-5 pellet

NAVSEA WARFARE CENTERS INDIAN HEAD



Silicon Bridge Testing

- Flyer successfully initiated thin layer of EDF-11 (15/17 times in various geometries / thicknesses)
- EDF-11 successfully initiated PBXN-5 pellet (4/6 times)
- Dent block analysis underway at NSWC IH



Initiator with Aluminum Dent Block

Dent Block After Successful Charge Transfer

Summary

- M100 Drop-In Replacement
  - More Reliable (σ=0.0220 V)
  - Meets Firing Requirements
    - All-Fire at 1.6 V off 100µF cap
    - No-Fire at 0.7 V off 100µF cap
- Silicon Bridge Initiator
  - Successfully Initiated Explosive Train
  - Semiconductor processing: Firing characteristics can be easily changed per application
  - Fast Acting (µs range), Low Energy (~5 mJ), Very Efficient