



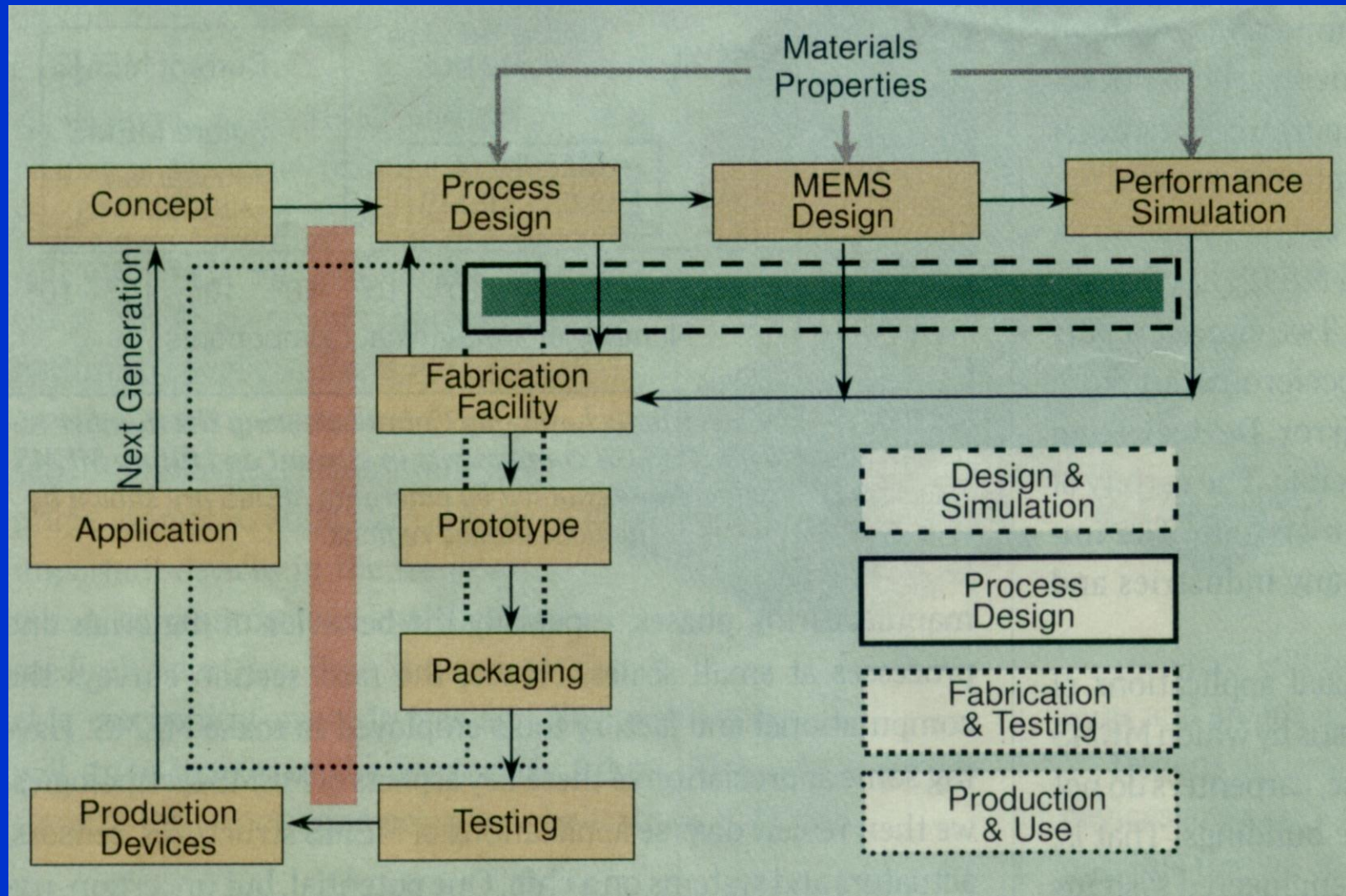
Tehnologije mikrosistema

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Doc. Dr Vesna Paunović



Realizacija mikrosistema

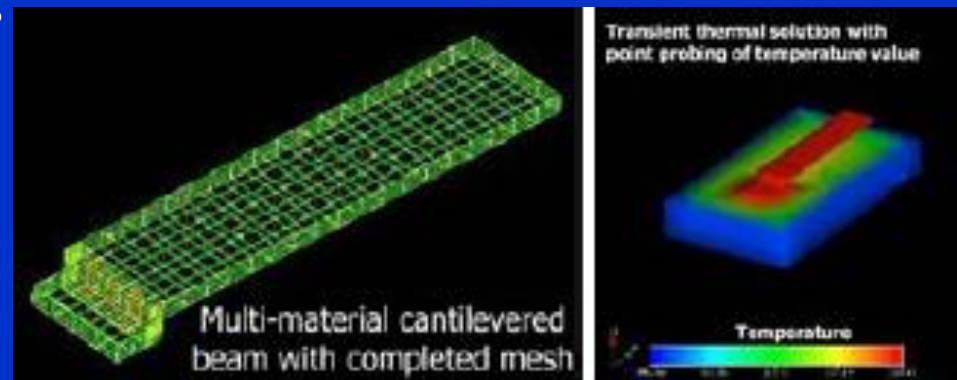
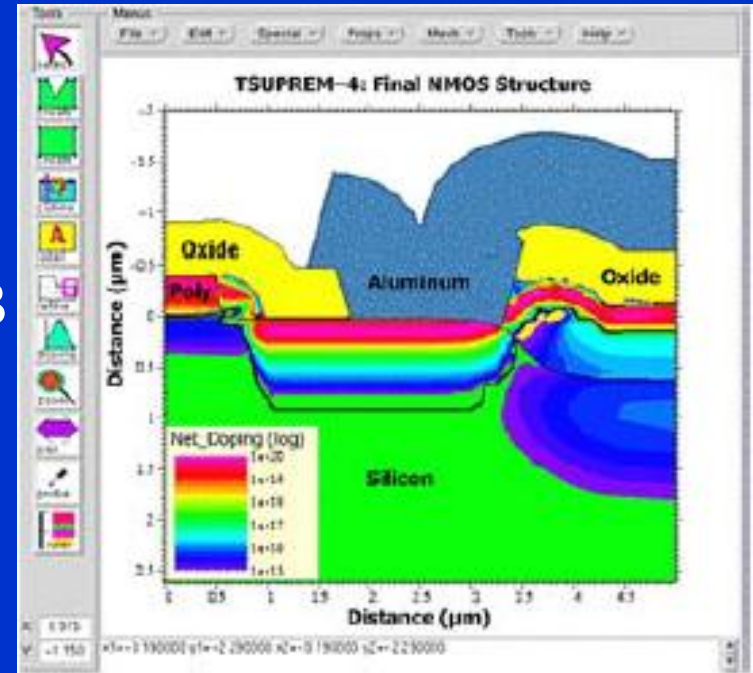


Tok dizajniranja i simulacije (zelena horizontalna osa) i proizvodnje (crvena vertikalna osa) mikrosistema



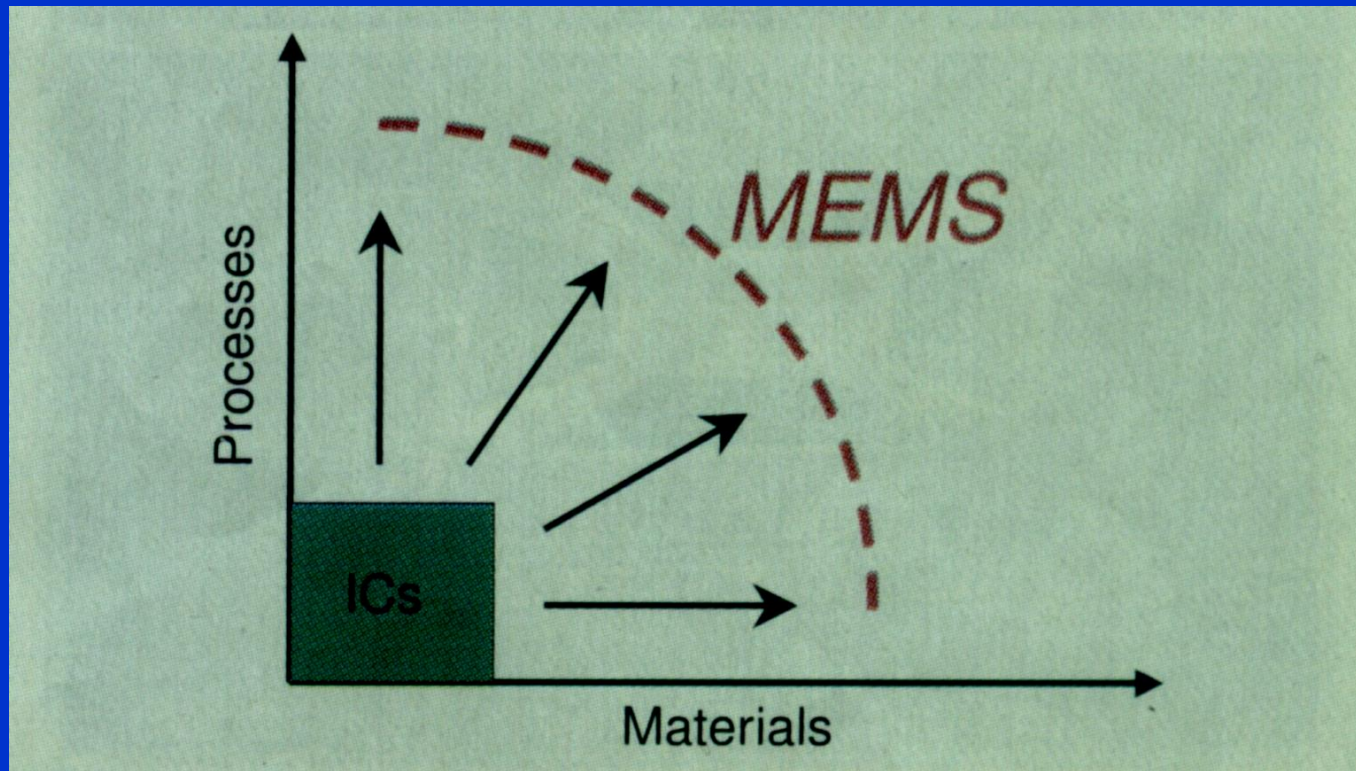
Softverski alati

- Dizajn komponenata
 - Cadence, LEdit, Spice, MATLAB
- Dizajn procesa
 - TSuprem, IntelliSuite, AnisE
- Analiza
 - FEM sistemi, MEMCAD, IntelliSuite, ANSYS





Poredjenje proizvodnje mikrosistema i IK





Materijali u proizvodnji mikrosistema

- Supstrati:

- Silicijum (Si)
- Galijum-arsenid (GaAs)
- Drugi elementarni poluprovodnici i poluprovod. jedinjenja
- Metali
- Stakla
- Kvarc
- Safir
- Keramika
- Plastika, polimeri i drugi organski materijali

- Aditivni materijali:

- Si (amorfni, polikristalni, epitaksijalni)
- Jedinjenja Si (oksidi, nitridi, karbidi)
- Metali i njihova jedinjenja
- Stakla
- Keramika
- Polimeri i drugi organski materijali
- Biomaterijali



Tehnologije mikrosistema

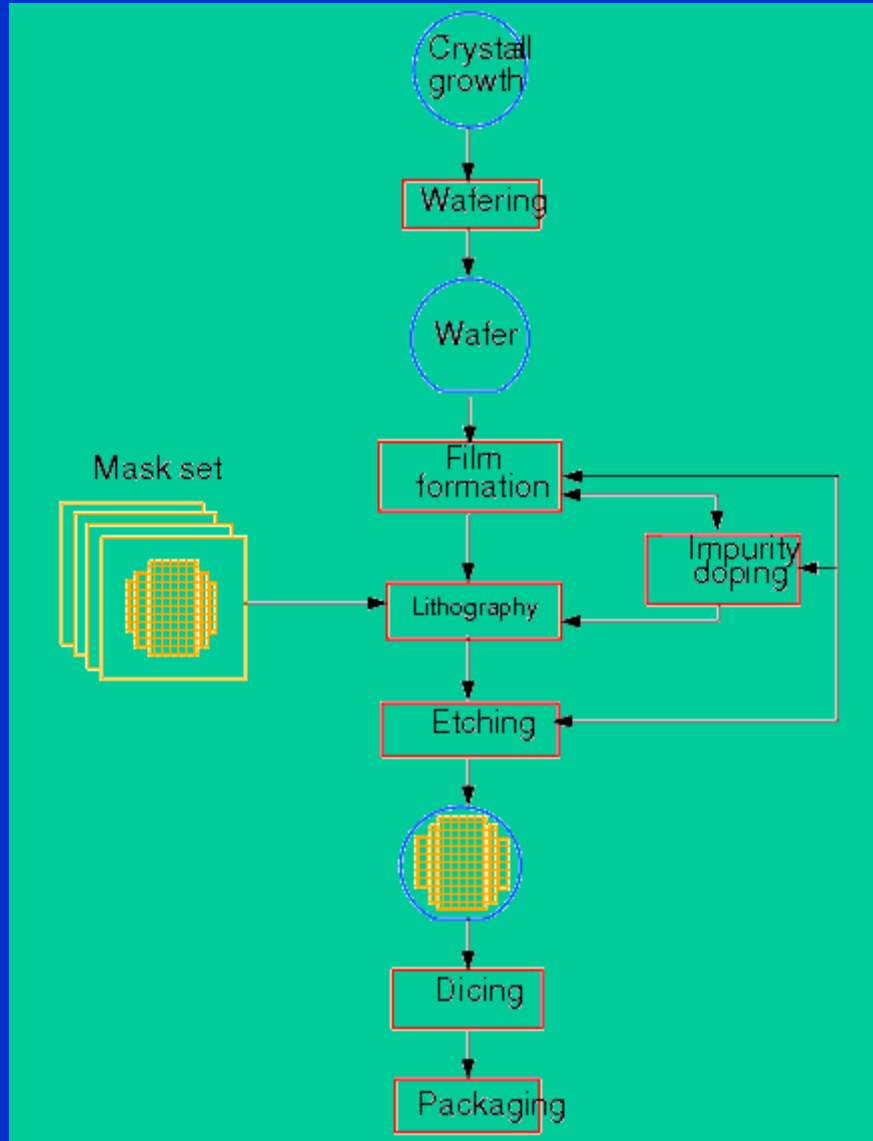
Tehnologije IK

Tehnologije mikromašinstva

- Površinsko mikromašinstvo
 - MUMPS i SUMMiT tehnologije
- Zapreminsko mikromašinstvo
- HARM tehnologije
 - DRIE
 - LIGA
 - Bondiranje pločica



Procesi u tehnologiji IK



Procesi na pločicama

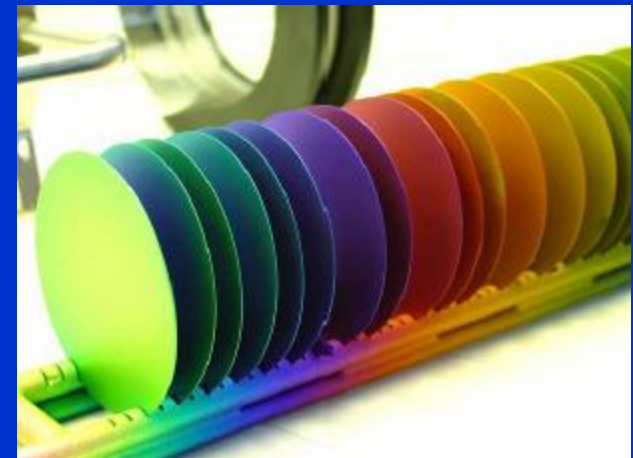
1. Depozicija/rast tankih filmova
2. Patterning tankih filmova
3. Dopiranje primesa



Procesi u tehnologiji IK

1. Procesi depozicije/rasta tankih filmova

- **Spin-on**
 - Fotorezist
 - Poliamidni filmovi
- **PVD (Physical Vapour Deposition)**
 - Naparavanje (evaporation)
 - Katodno raspršavanje (sputtering)
- **CVD (Chemical Vapour Deposition)**
 - Oksidacija
 - LPCVD (Low Pressure CVD)
 - PECVD (Plasma Enhanced CVD)

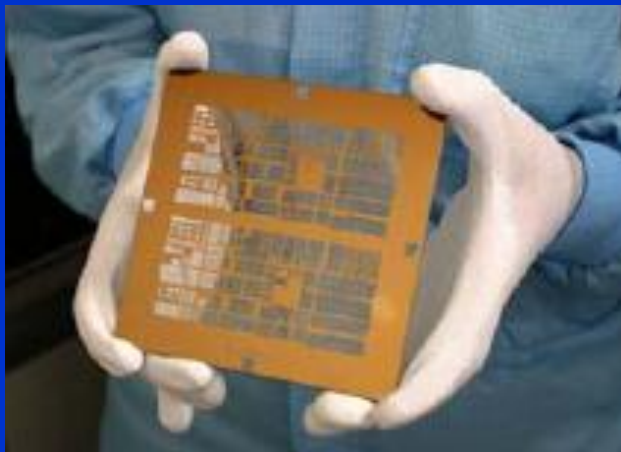
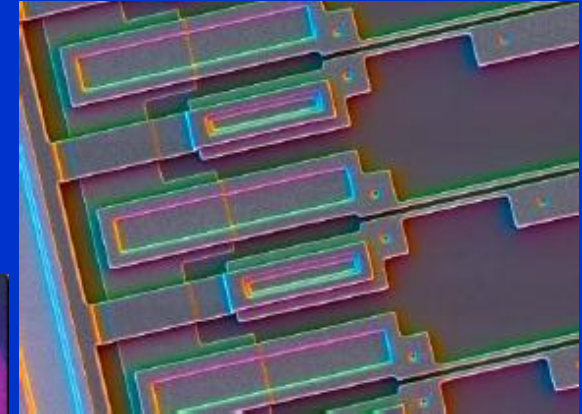
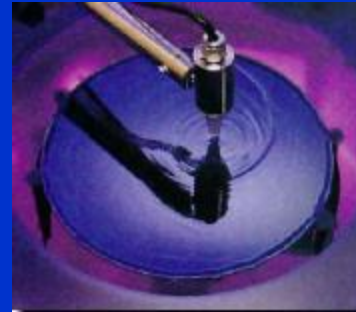




Procesi u tehnologiji IK

2. Patterning tankih filmova

- Litografija
 - Optička (UV svetlost)
 - Snopom elektrona
 - Snopom X-zraka
- Nagrizanje (etching)
 - Vlažno (wet)
 - Suvo (dry)
 - RIE (Reactive Ion Etching)

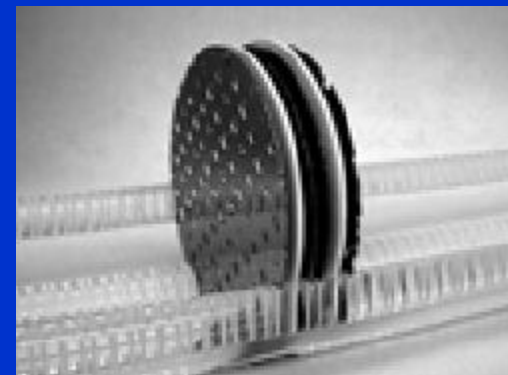
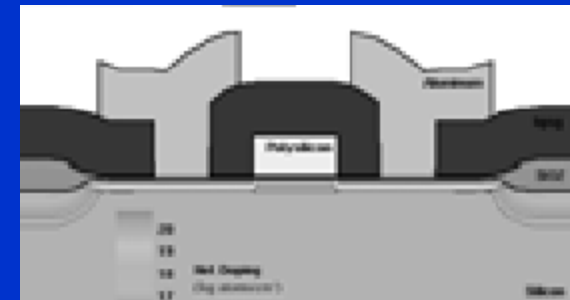




Procesi u tehnologiji IK

2. Dopiranje (uvodjenje primesa)

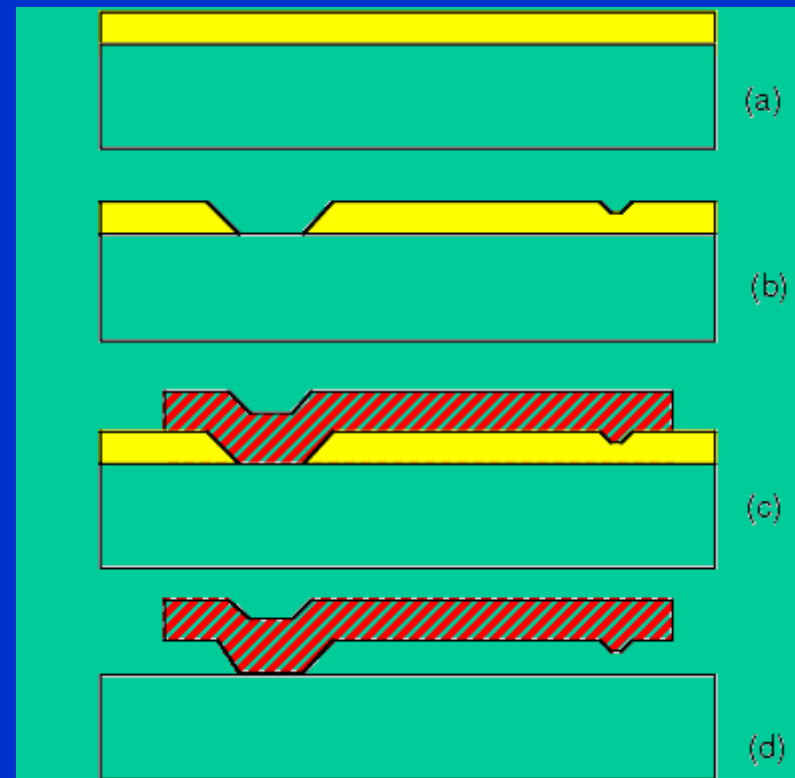
- Termička difuzija
- Jonska implantacija





Površinsko mikromašinstvo

- Aditivni procesi
- Strukturni i pomoćni slojevi



Šematski prikaz površinskog mikromašinstva. (a) Depozicija pomoćnog (sacrificial) sloja, (b) patterning pomoćnog sloja, (c) depozicija i patterning strukturnog sloja, (d) nagrizanje pomoćnog sloja i dobijanje samodržee strukture



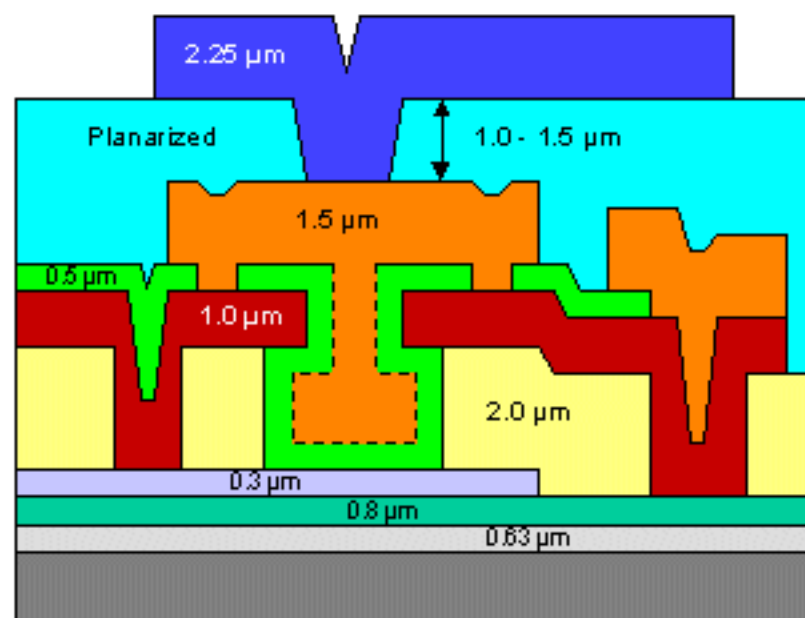
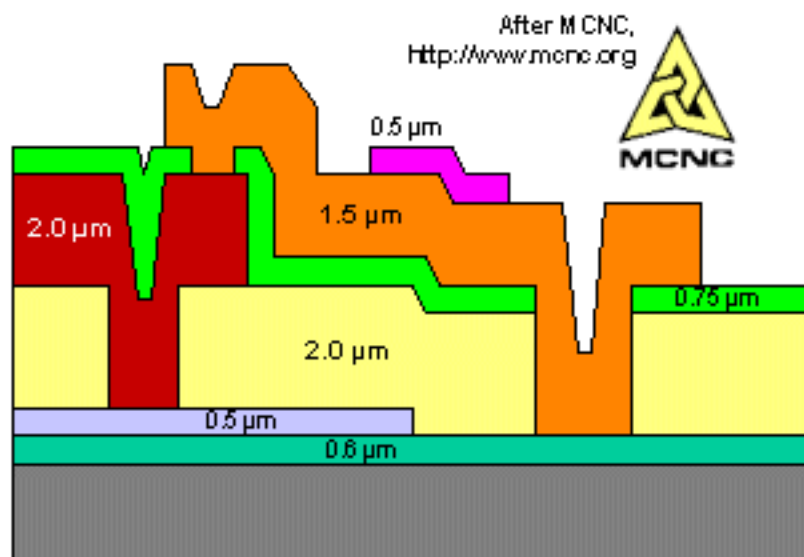
MUMPS i SUMMiT tehnologije



Multi-User MEMS Process
(MUMPS)

Sandia Ultra-planar Multi-level MEMS Technology
(SUMMiT)

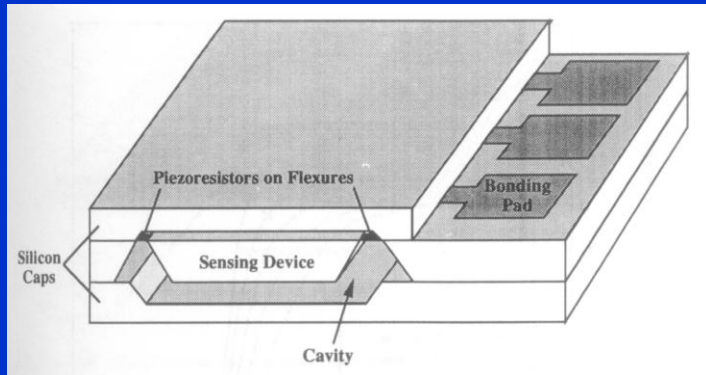
(Upper levels and advanced features are not available.)





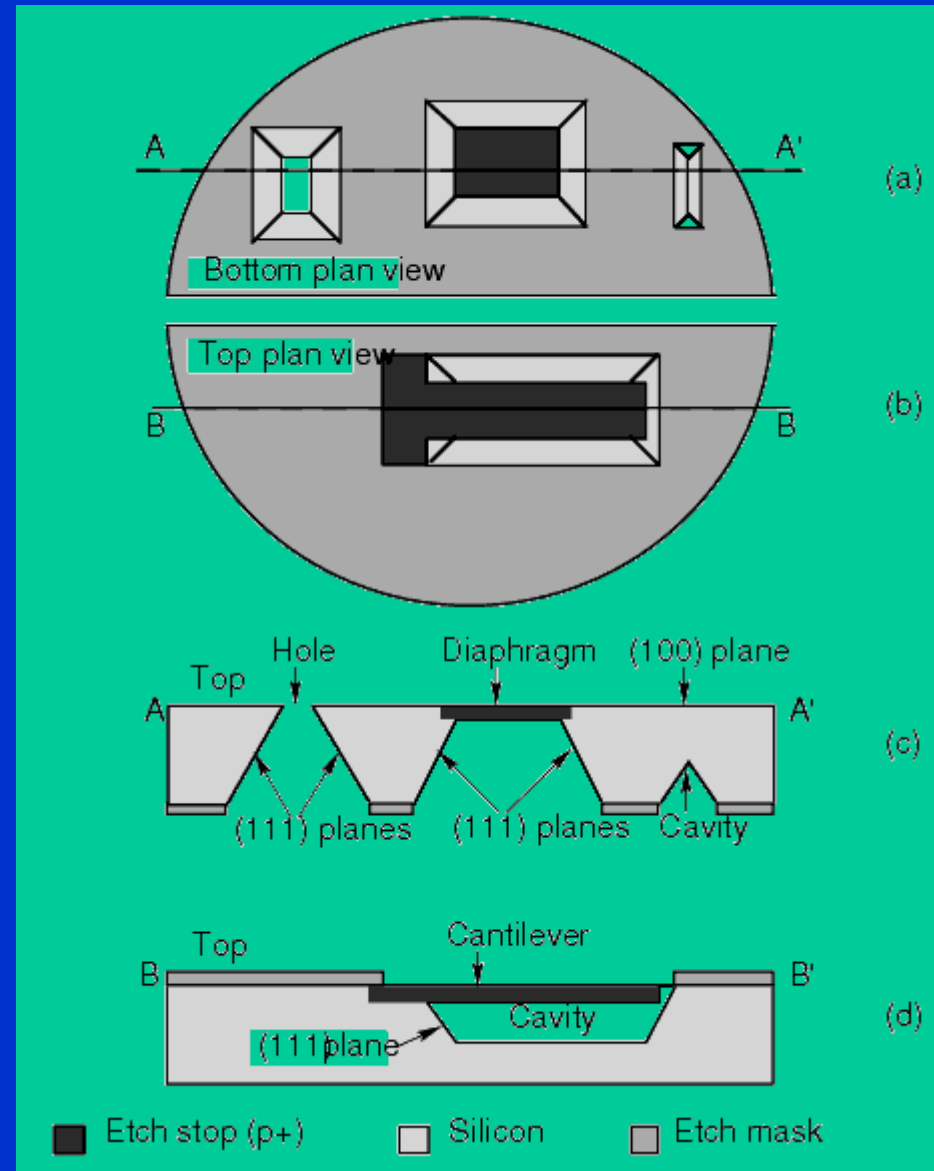
Zapreminsko mikromašinstvo

- Procesi oduzimanja materijala
- Vlažno i suvo nagrizanje
- Izotropno i anizotropno nagrizanje



Akcelerometar realizovan tehnologijom zapreminskog mikromašinstva

Strukture realizovane anizotropnim nagrizanjem silicijuma.
 (a) Donja strana pločice sa šupljinama, dijafragmom and otvorom;
 (b) Gornja strana pločice sa kantiliverom formiranim etch-stop tehnikom;
 (c) poprečni presek AA' i
 (d) poprečni presek BB'.



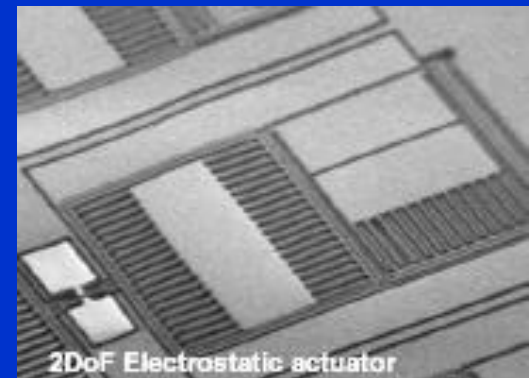
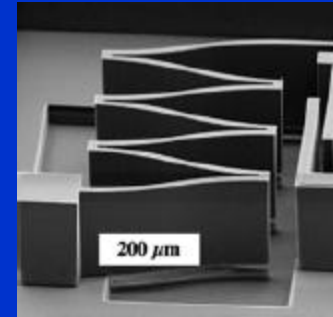


HARM tehnologije

High Aspect Ratio Micromachining (HARM)

– veliki odnos visine i širine struktura -

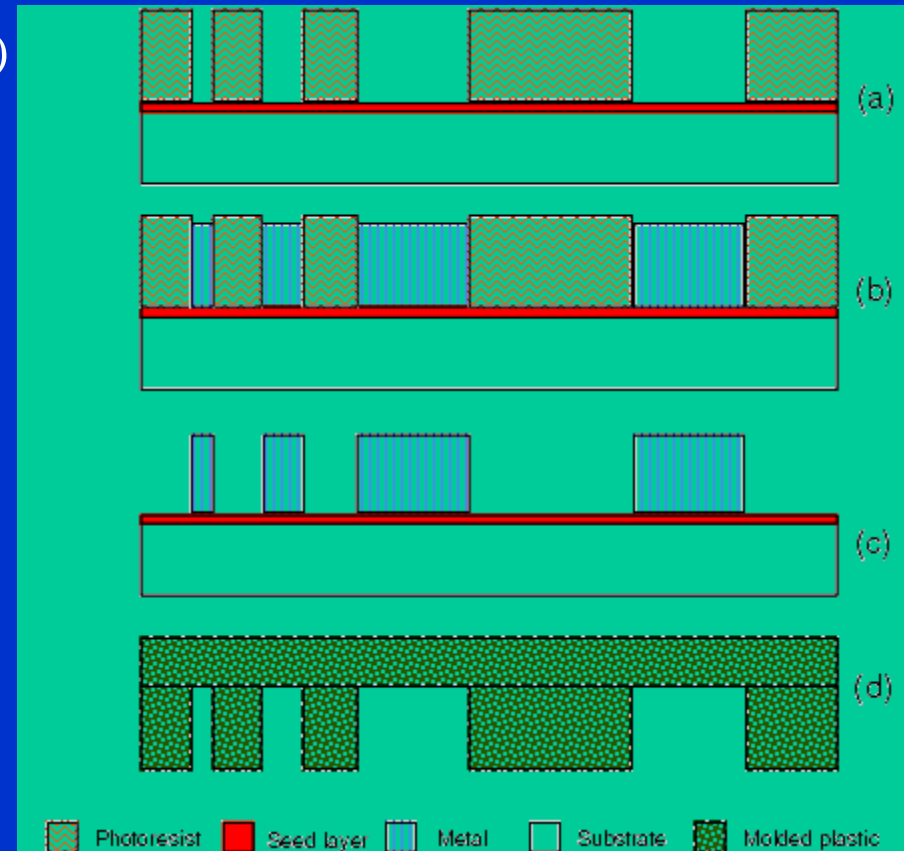
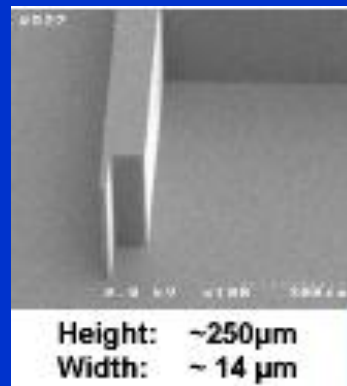
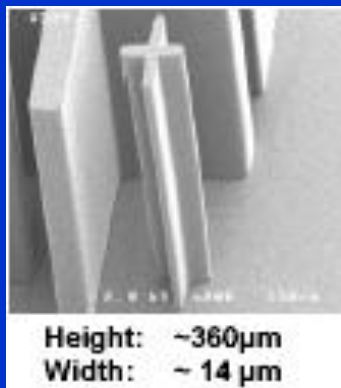
- DRIE – (Deep Reactive Ion Etching)
 - Duboko RIE nagrizanje -





HARM tehnologije

- LIGA - Lithographie Galvanoformung Abformung
(Lithography, Electroplating, Molding)



LIGA tehnologija. (a) patterning rezista X-zracima, (b) elektro-depozicija metala, (c) nagrizanje rezista, i (d) formiranje plastičnih komponenata.



HARM tehnologije

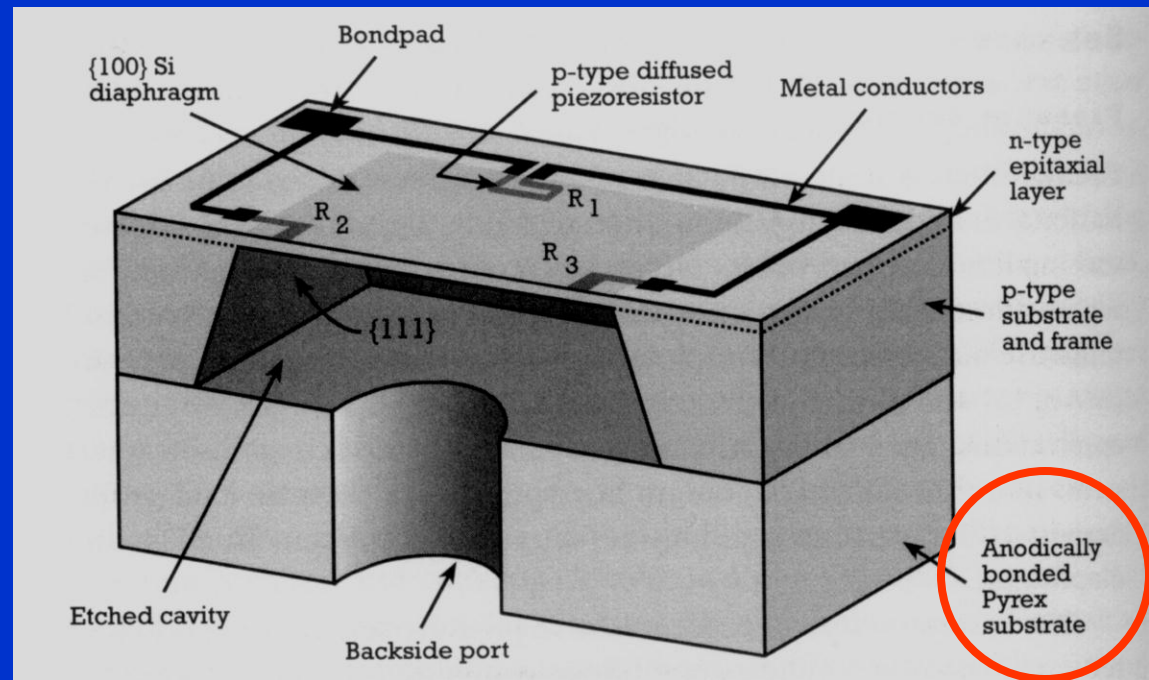
- Bondiranje pločica

- Anodno bondiranje

- Spajanje Si sa staklom i dr. materijalima

- Fuziono bondiranje

- Spajanje dve Si pločice



Senzor pritiska.