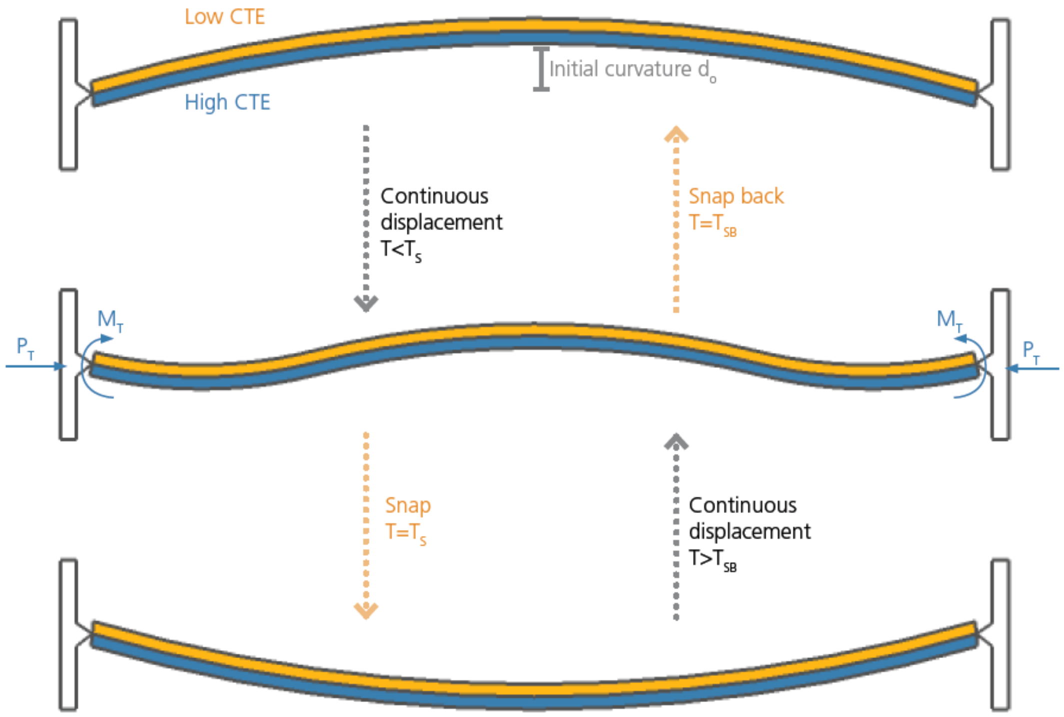
29/01/2014

PTA clean room
Process proposition

Arthur Arnaud

life.augmented



The most important parameters are:

- The expansion coefficient of both materials
- The ratio of the beam thickness and of the initial deflexion t/d
- The curvature of the beam d/L

Bimetals with
- very small hysteresis ***3-4°C***
-Temperatures around ***100°C***

What do we want?

- It must enable to curve a beam and to ***control the curvature***
- The materials used must expand ***very fast*** *or* ***very slow***

What kind of process do we need?

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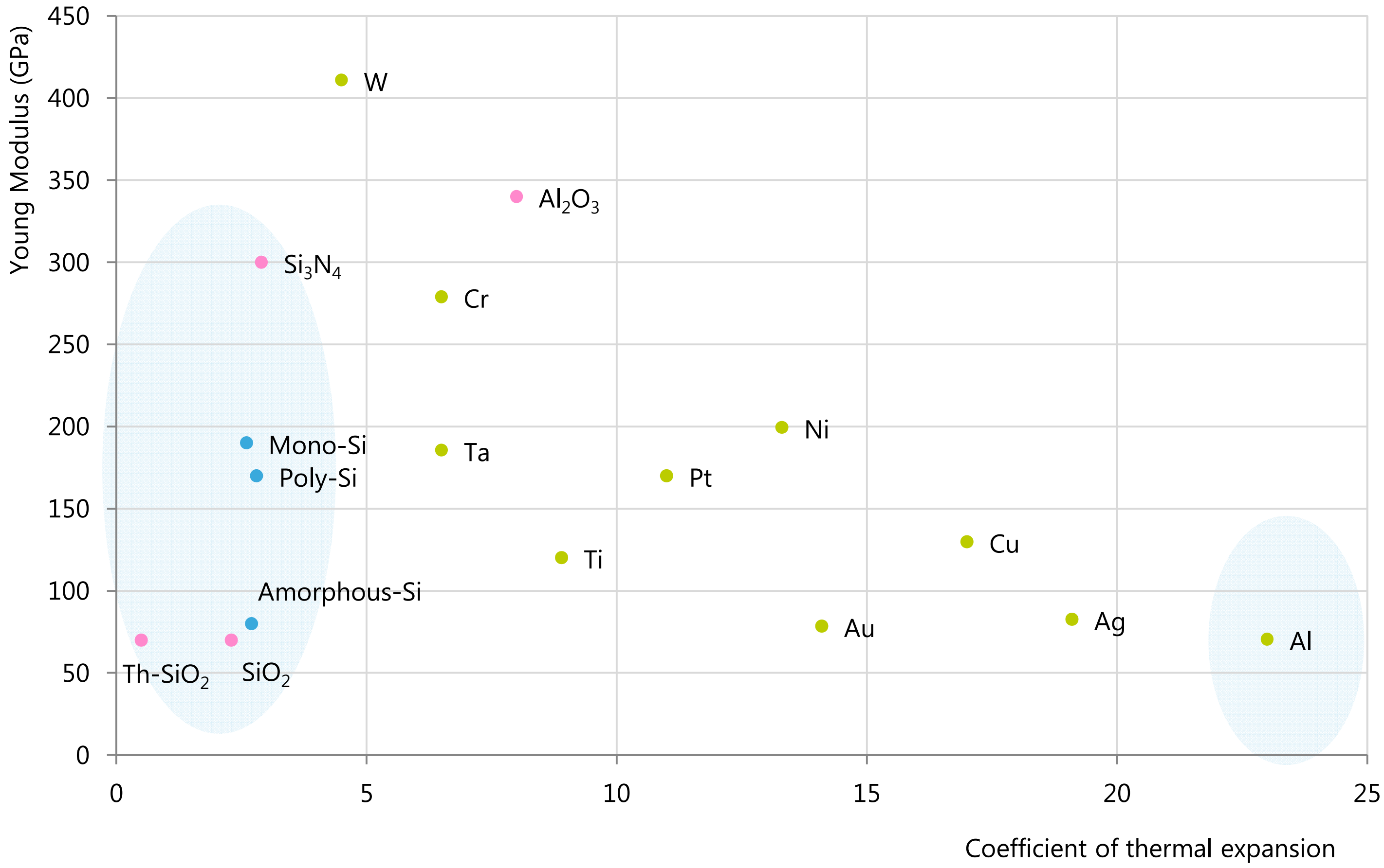
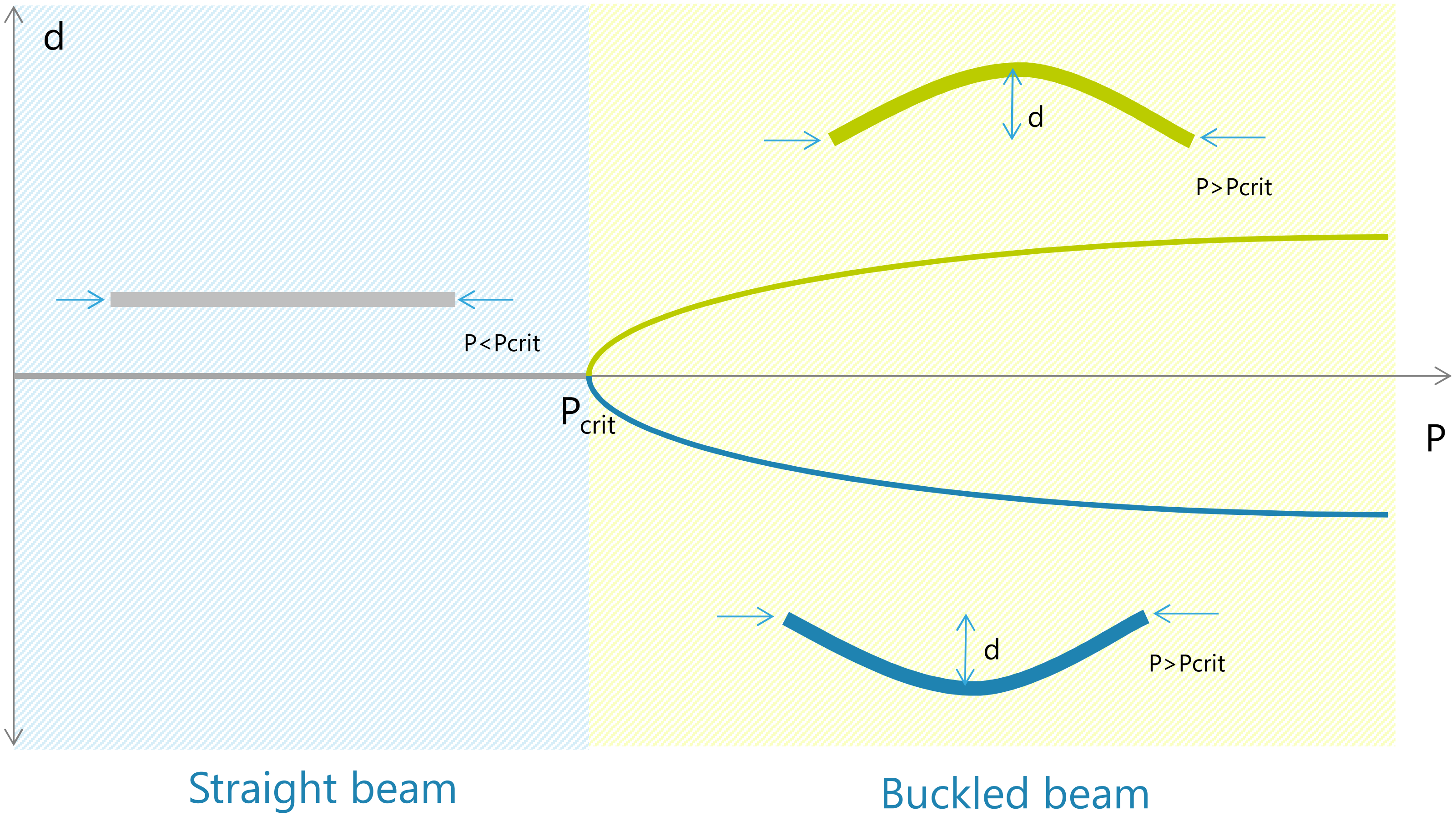
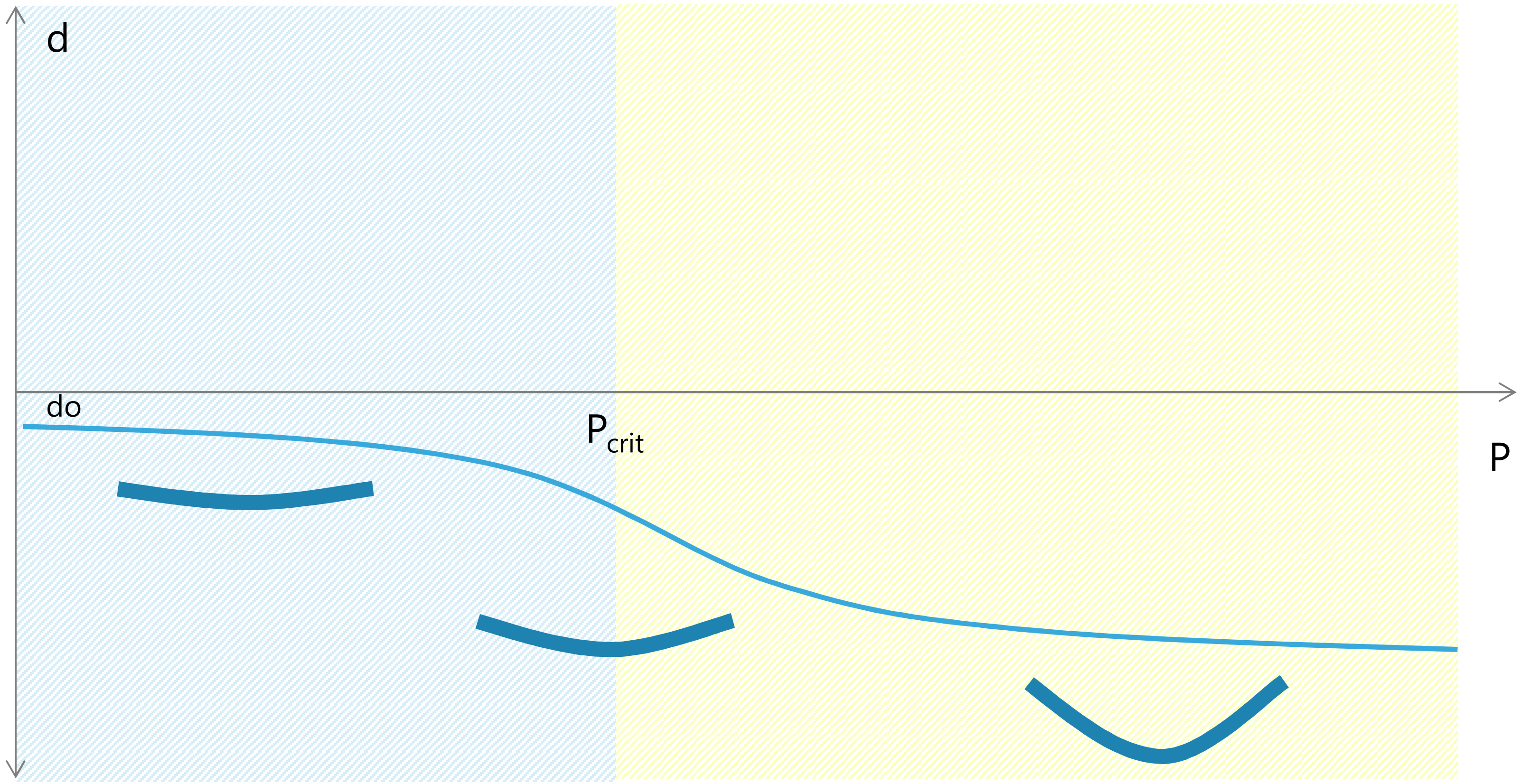


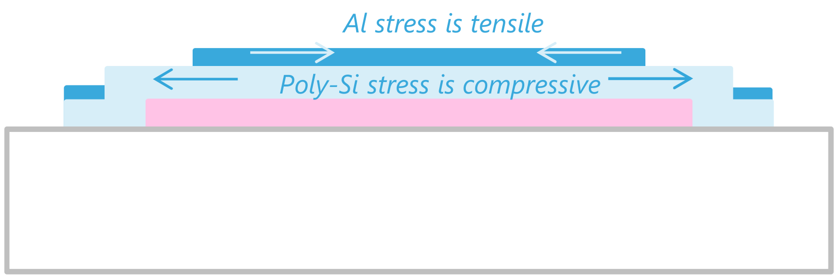
Coefficient of thermal expansion vs. Young modulus for different materials

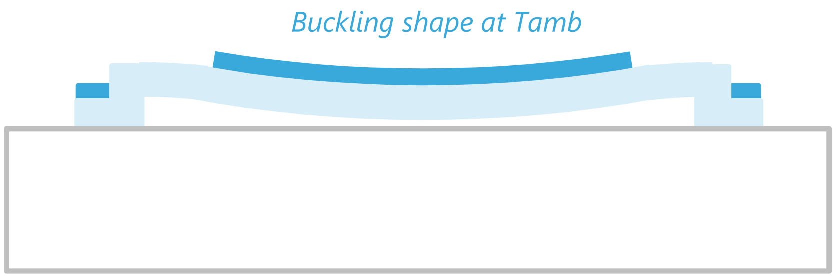


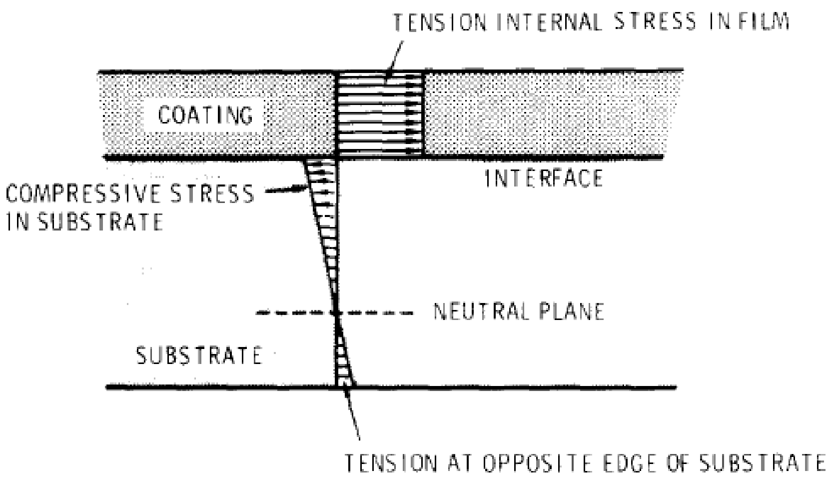
Euler's beam buckling. *When the compressive stress exceeds a critical value, a straight beam stops being compressed but tends to buckle either top or down.*



Imperfect beams buckling. *An imperfection like an initial curvature or an assymmetry in the beam or stress distribution modifies the behaviour of the beam*







- The tensile Al film serves as an imperfertion for the buckling of the beam

- The current analytical model must be modified to take into account the buckled shape as well as the value of the residual stress in both layer to properly design the beam and choosing the process conditions

1. LPCVD PSG layer 400°C ->100Å/min
2. Densification 950°C O_2 ambient
30 min - 1h

Or

1. LPCVD LTO SiO_2 400°C

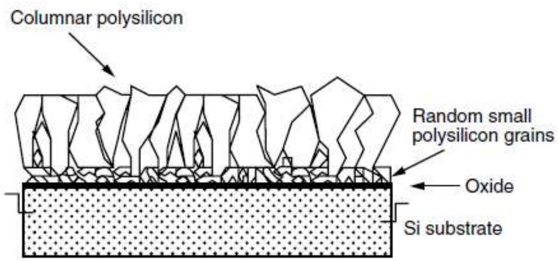
Advantages of the first method:
- *Higher etch rate in HF and selectivity*
- *Possibility of doping Si-Poly thanks to PSG*
- *Reduced intrinsic stress in PSG*

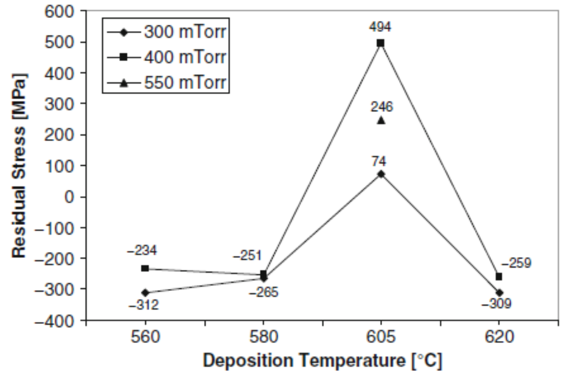
Sacrificial oxide patterning using plasma Cf4 O2 or wet etching using HF

Influence on the lenght of the beam and shape of the walls. Which impact on the bimetal working?

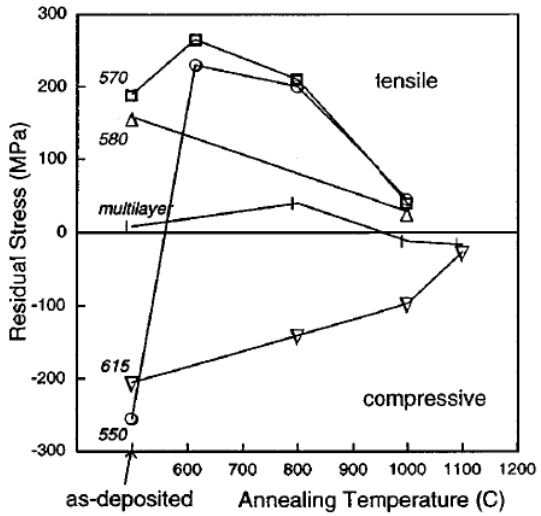
1. LPCVD poly-silicon deposition 615°C
2. Poly-Silicon doping
3. Stress reduction annealing

4. Poly-Si patterning using SF6 RIE

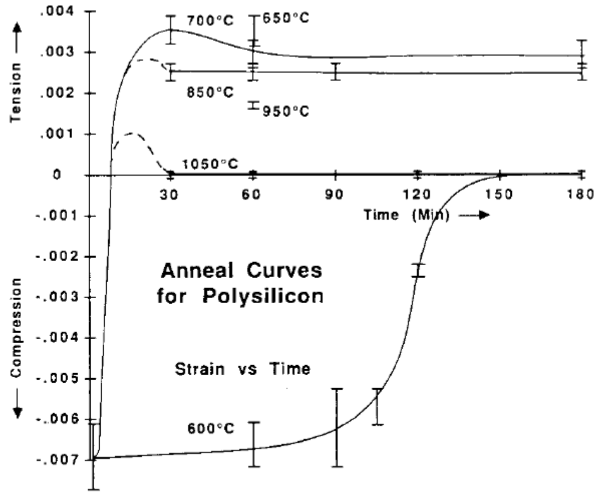




Ghodssi 2010- Impact of the deposition temperature on the stress



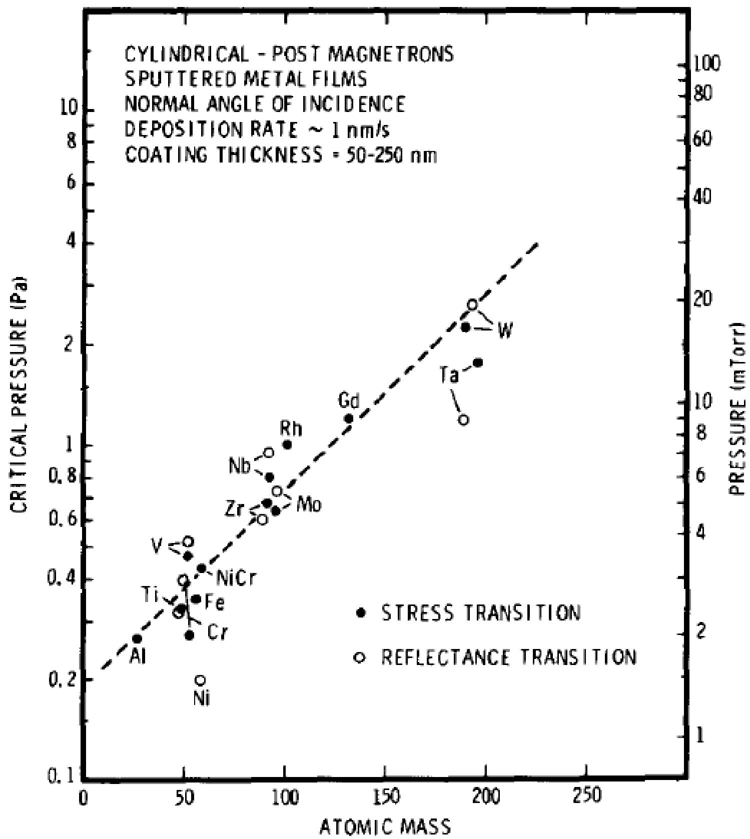
Yang 2000- Residual stress in function of the anneal temperature after a 30min anneal in N2



Guckel 1988- Residual stress in function the anneal temperature and temperature for poly-Si deposited at 580°C

4. Poly-Si patterning using SF6 RIE

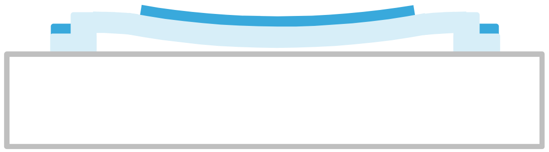
5. Al layer sputtering



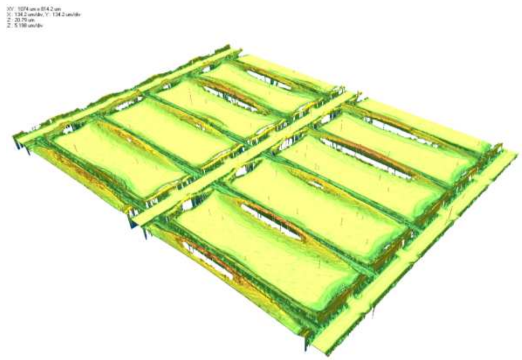
Thornton 1989- Transition tensile stress/compressive stress in metal layers for

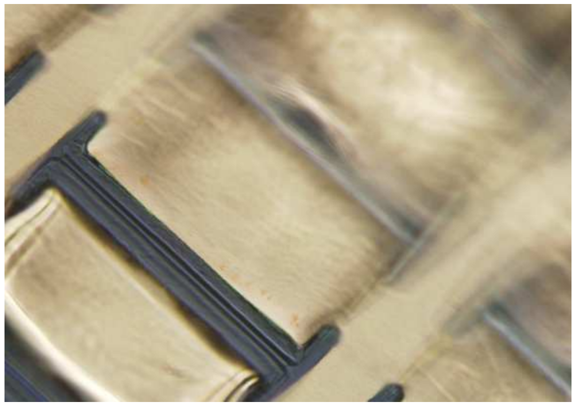
By sputtering, possibilities of adjusting the stress value by varying the reactor pressure, the target power…
Competition between the intrinsic stress (compressive) and the tensile stress caused by the thermal mismatch

6. Al layer patterning using HCl/HNO3
-> High selectivity compared to Si, SiO2 and Al2O3



7. Sacrificial layer etching using HF
8. Supercritical drying to avoid stiction and membrane failure



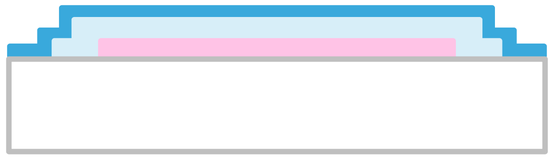


1. LPCVD PSG layer deposition and reflow or SIO2 if impossibility of depositing PSG

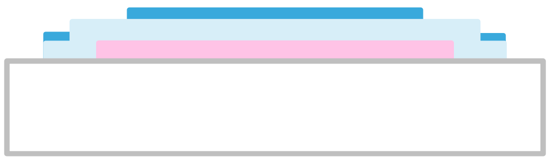
2. Sacrificial oxide patterning

3. LPCVD poly-silicon deposition doping and annealing

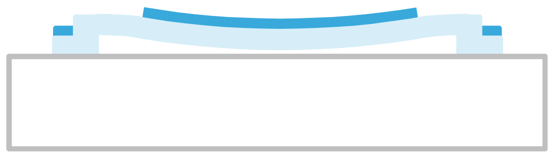
4. Poly-Si patterning using RIE



5. Al layer sputtering or evaporation

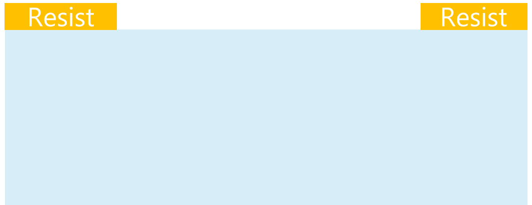


6. Al layer patterning using wet etchant

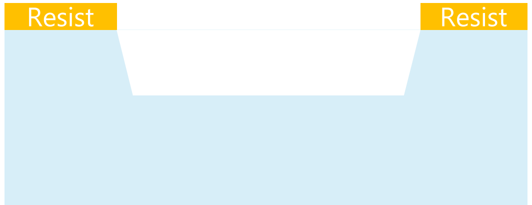


7. Sacrificial layer etching using HF vapor

Trenches definition with sacrificial material filling

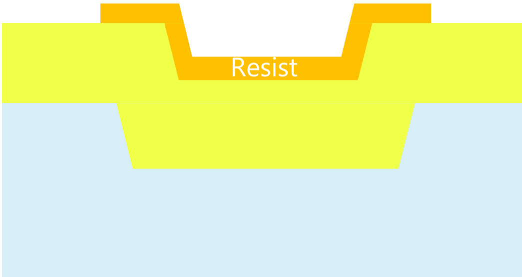


1. Trenches definitions using Microlenses mask

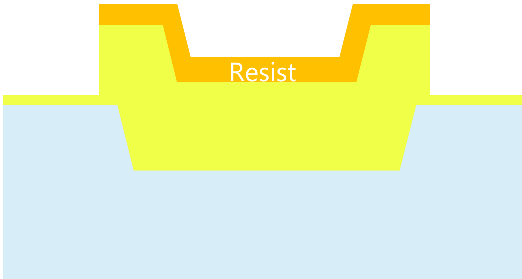


2. Trenches opening in the substrate using dry etching

3. Trenches filling with SiO_2 TEOS as a sacrificial layer



4. opposite sign resist lithography equivalent to the use of a counter mask



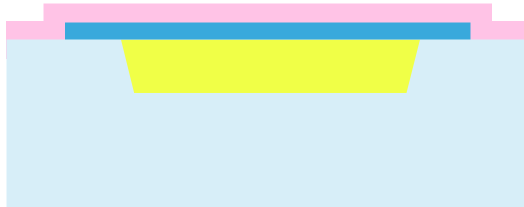
5. Wet etching of SiO_2 excess around the trench

6. CMP of the oxide with partial etching of the substrate

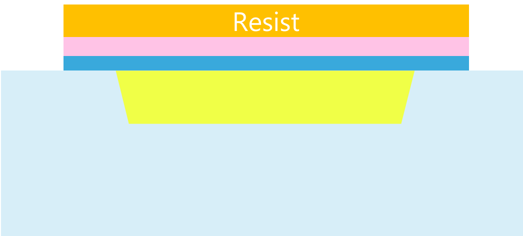
Bimetals fabrication

6. Si layer deposition -> needs for controling the compressive stress

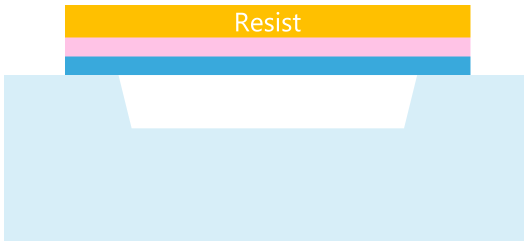
7. RIE etching of Si layer



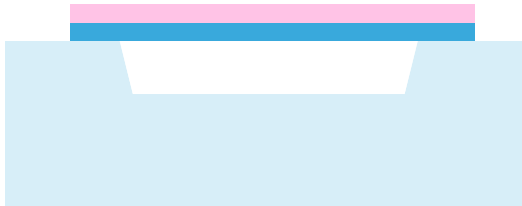
8. Al layer PVD deposition



9. Al layer etching



10. SiO2 layer etching using HF



10. Mask layer removal