Alignment Sensors

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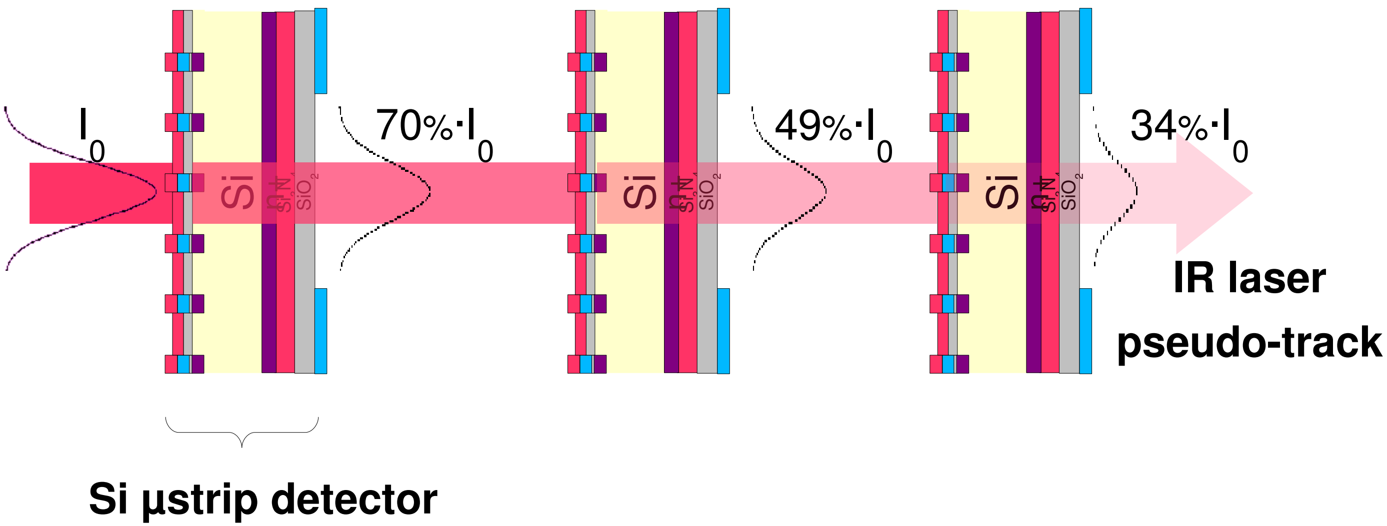
Outline

(Brief) reminder of the alignment system

(Optical) characterization of Si μstrip materials

Further details:	Eudet-memo-2007-32
Latest talk at ECFA08:	Slides

Main idea...



Currently: T<54% (AMS)

Our design goal:
T=70% with Al strips
T=75-80% with ITO strips

- Novel idea: (hardware) track alignment using IR laser beams

Further alignment accuracy obtained with real tracks

- Already used by AMS and CMS

- IFCA-CNM enters in SiLC collaboration with 2 handles:
  - — implements minimum set of modifications needed to produce alignment friendly sensors
  - — study group of modifications that lead to highly transparent alignment sensors

Simulation and fitting

Developed an optical simulation of the sensor. Includes:

— **interferences** due to multiple reflections in each layer

— **diffraction** of light by the strips (=diffraction grating)

— Input needed: N(λ)=(n(λ),k(λ)) and layer thickness (d)

Included optimization, featuring:

— spectral width of the laser

— thickness tolerance of the layers

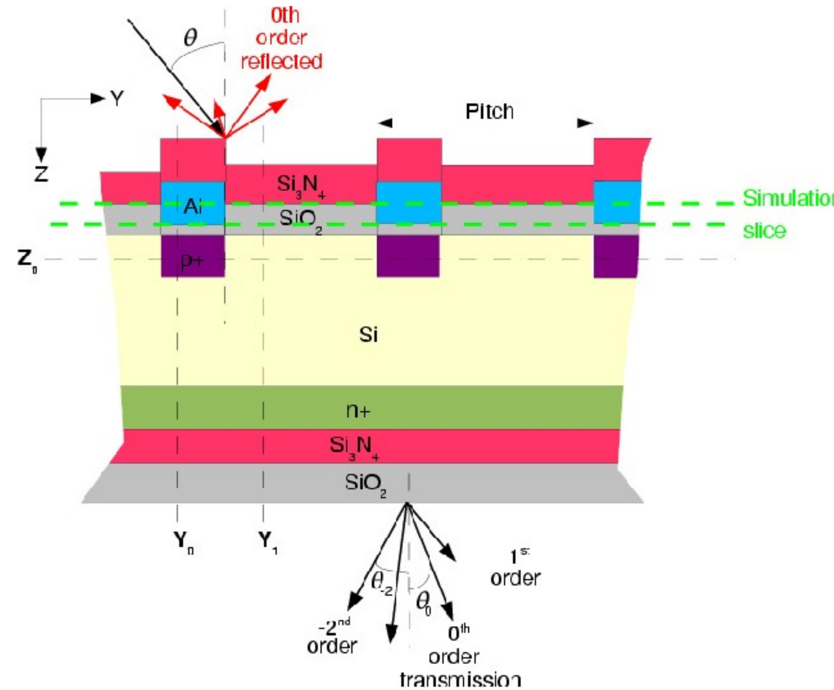
Simulation can be used in both directions:

→ from tabulated values we can predict (T(λ),R(λ))

Tabulated (n,k,d) } Simulation → $T_{sim}(\lambda)$, $R_{sim}(\lambda)$

← from measured results we can infer (N(λ),d)

$T_{meas}(\lambda)$, $R_{meas}(\lambda)$ } Simulation → Fitted (n,k,d)

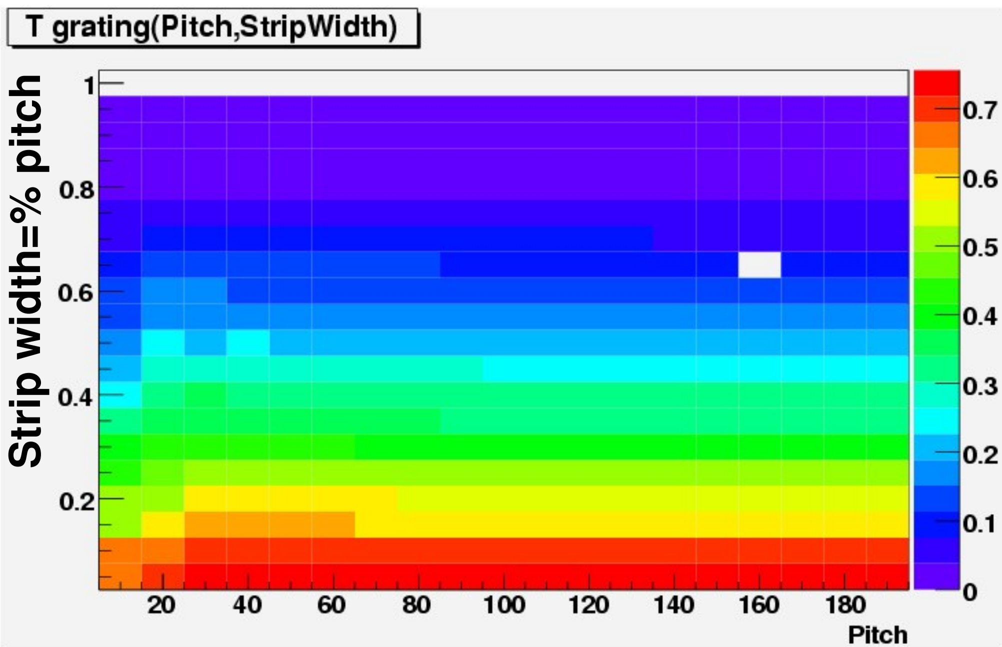


Further details: Eudet-memo-2007-32

Example of simulation predictions

• Finding out best **strip width** to **pitch** ratio for maximum %T

• T(pitch,strip_width), with strip_width expressed as percentage of the pitch
Using Al strips:



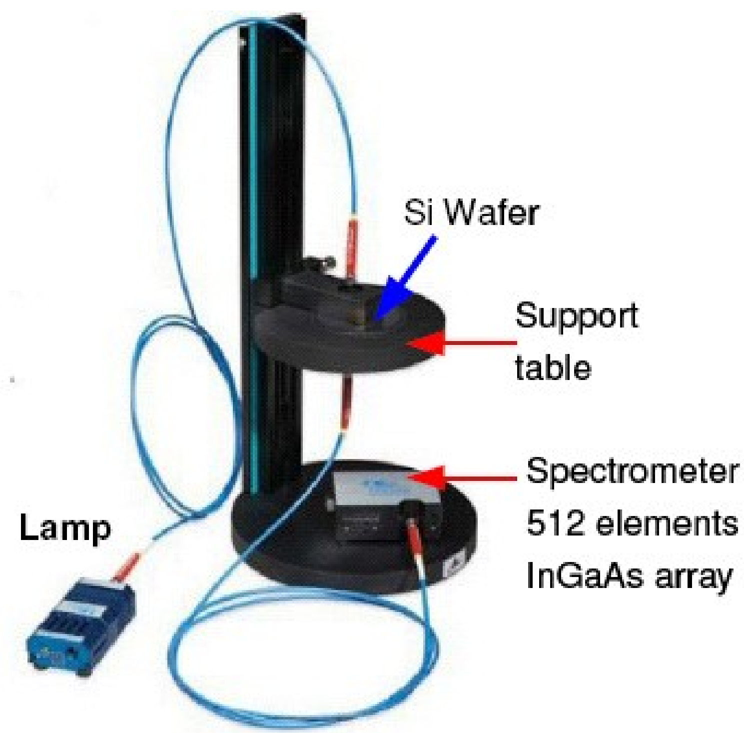
• The less Al, the more transmittance. Good compromise: **strip_width = 10% · Pitch**

IMB-CNM prototypes

- We are now interested in using the simulation in reverse sense. From measured (T(λ),R(λ)) we want to extract the optical constants of the materials

- INB-CNM Barcelona provided us with samples of each of the materials of the sensor (Si, Si_3N_4, SiO_2, ...) and different doping levels.

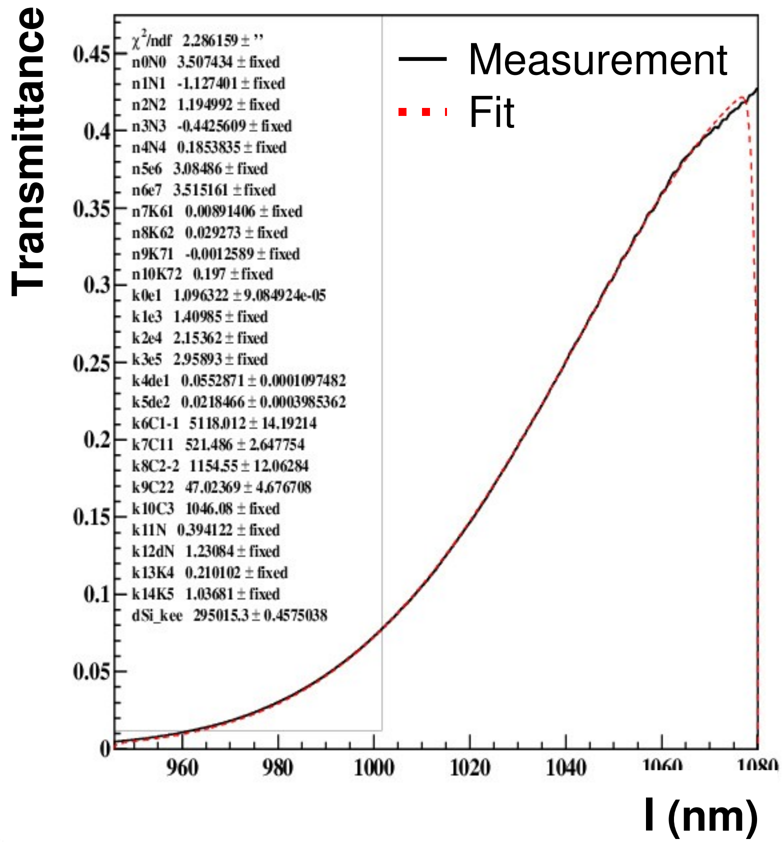
Manufacturing and processing granted by <u>Spanish Program to Access Large Research Facilities</u> (ICTS).

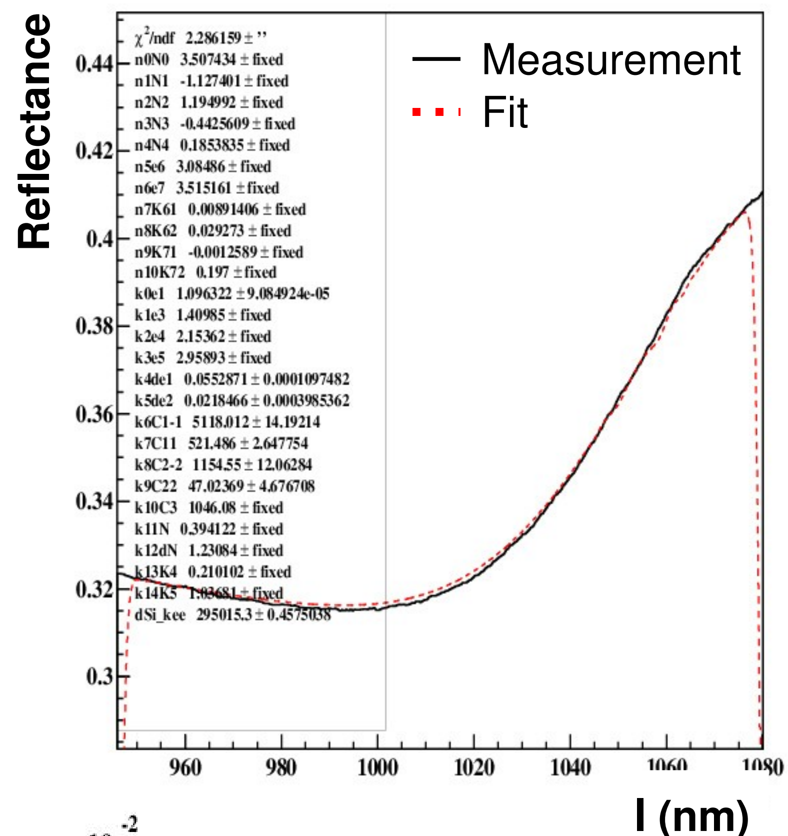


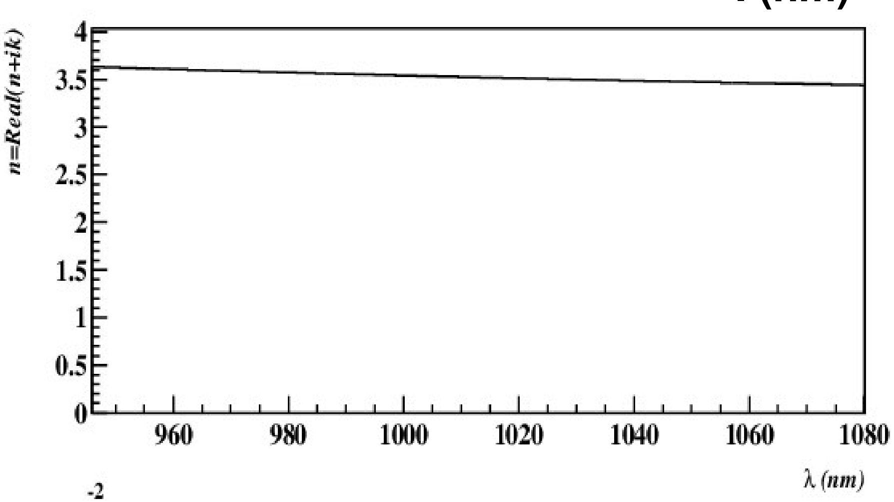
- Samples measured in Transmittance (%T) and Reflectance (%R) using custom designed grating spectrometer λ=[950,1150] nm ; σ_λ=1.2 nm

Fitted wafer (reverse sense)

- “n” is calculated from %R(λ<970 nm) data. Then T and R are then fitted simultaneously varying (k,d).







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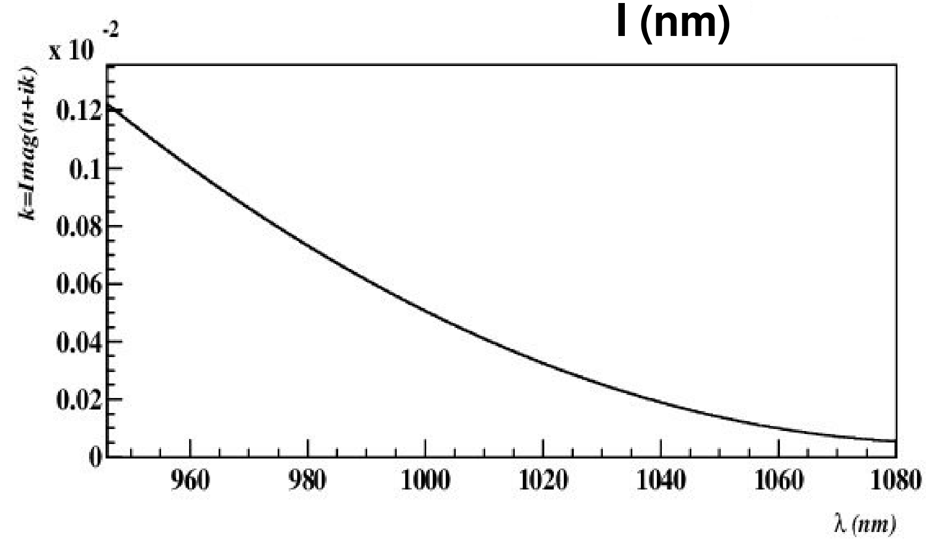


Some comments on the fits

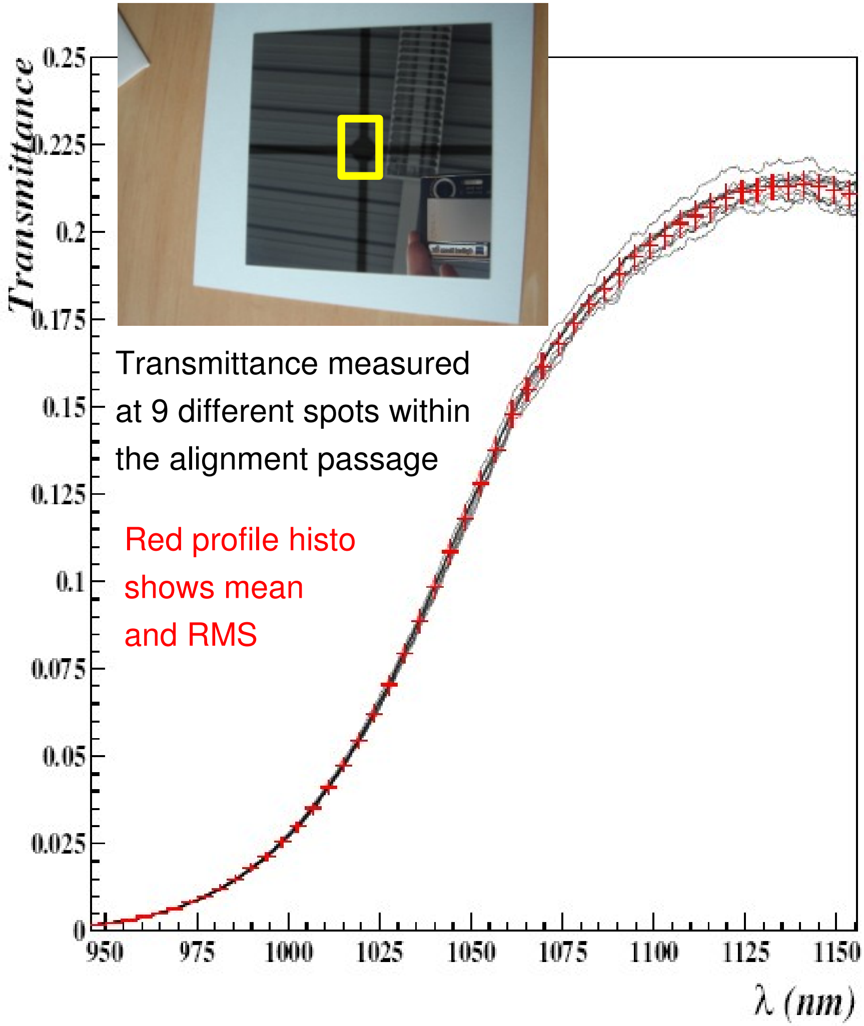
- Still problems extending the fit for λ in [1080,1150] nm.
  In this case, it is not possible to fit both %T and %R simultaneously as in the former plot

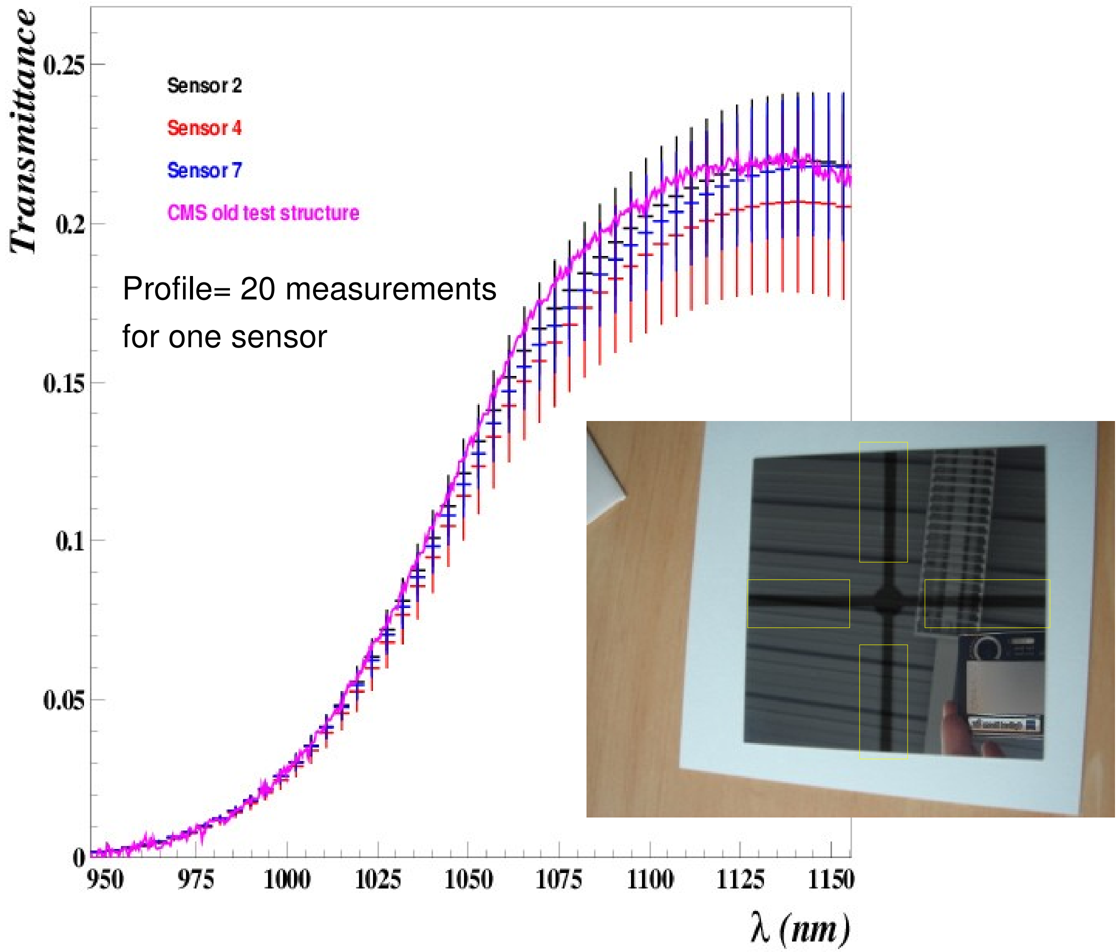
- Error propagation and detailed error analysis is only partially developed

- We know the error in %T, not in %R (to be measured as R=1-T)

%T for HPK new sensors

- CMS-like sensors: 50 µm pitch, 12.5 µm strip width, 312 µm thick
- They are alignment friendly, but not optimized for transmittance: no Anti-Reflection Coating (ARC).





Conclusions

• Si hybrid alignment systems are simple

• Realistic simulation accounts for interferences and diffraction processes

• Detailed error analysis is ongoing

• Measurements of HPK sensors shows uniformity of 2% within the alignment spot 10% across the alignment cross (not used by the system)

• The good news though, is that the characterization of the materials is the last step before designing the optimized prototype. We are close, but not yet there.

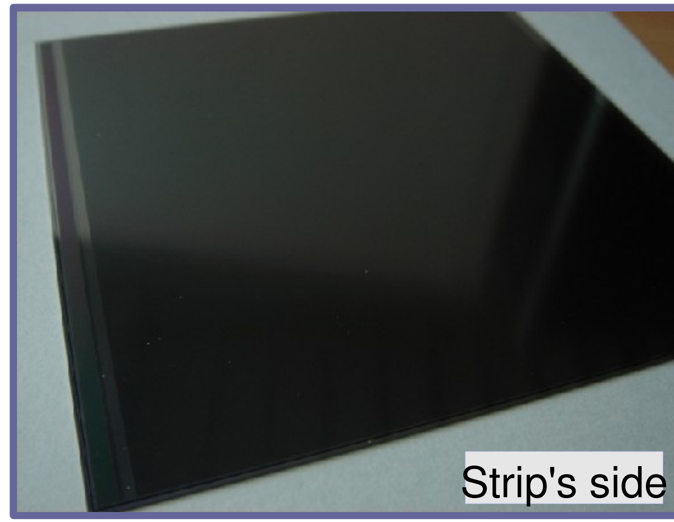
Backup

ILC: 2-fold approach

R&D on transparent Silicon µstrip sensors:

• Together with **IMB-CNM (Barcelona)** design, build and test new IR-transparent Silicon microstrip detectors.

• Consider option of aluminum electrodes or transparent electrodes



AMS-like approach:

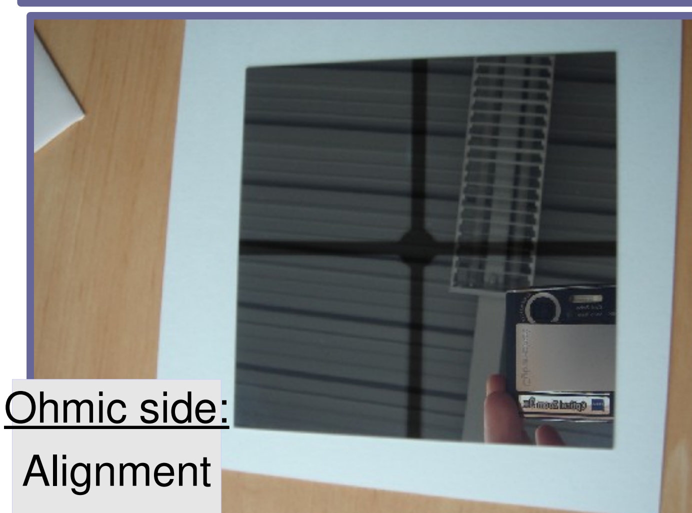
Baseline version: Minimum set of changes for
any SiLC sensors. For instance, for the new HPK

Implemented:

• ~10 mm window where Al back-metalization has been removed

Suggested (not cost effective for small batches):

• Strip width reduction (in alignment window)
• Alternate strip removal (in alignment window)



Ohmic side:
Alignment passage

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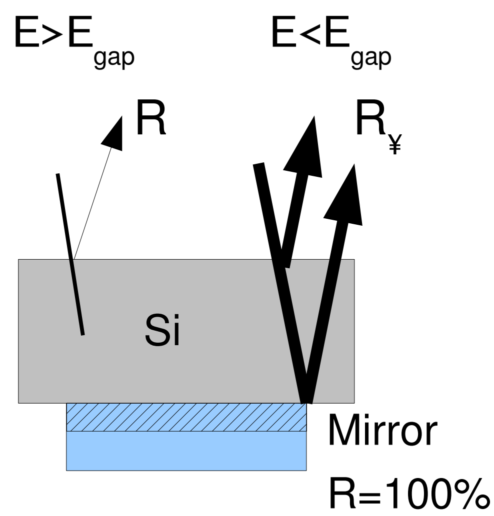
Calculating n

• Considered Si wafer here

• The real part of the refractive index can be calculated easily. Due to Si high absorption for $E>E_{gap}$, the photons do not reach the bottom surface Checked with a **mirror** on the Si wafer

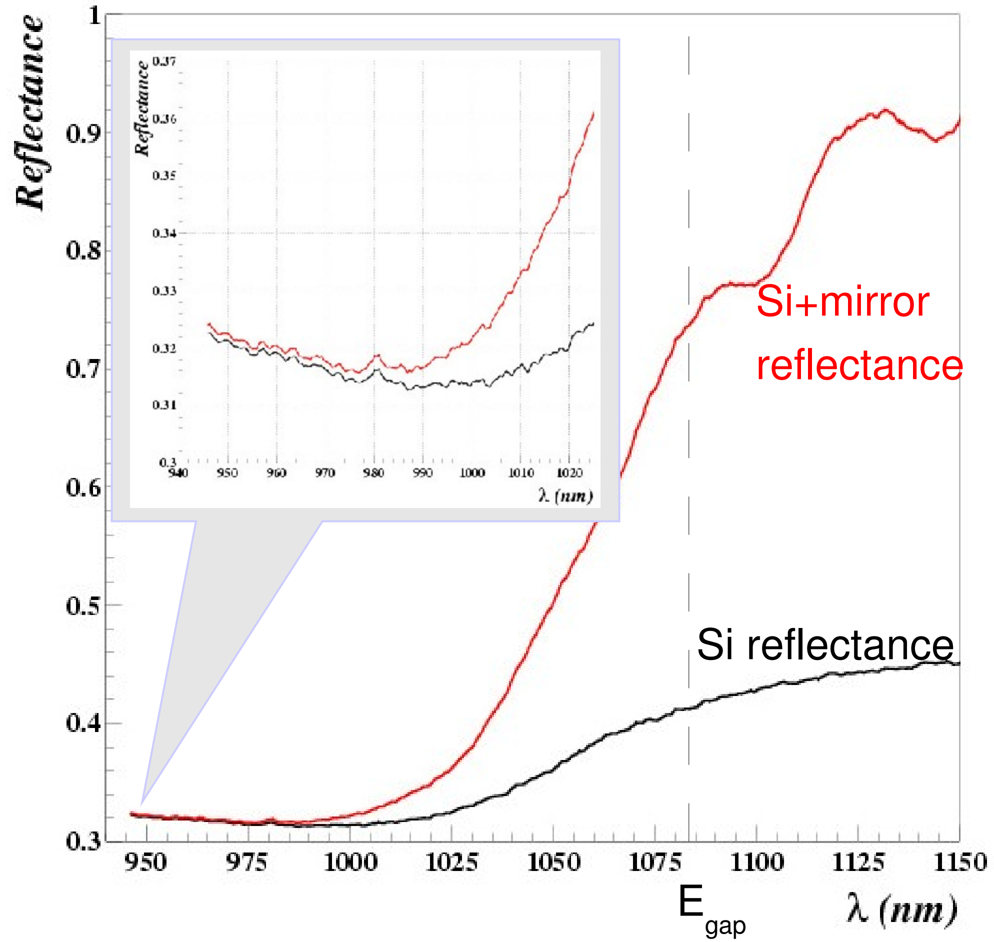


$$R=\frac{(n-1)^2+k^2}{(n+1)^2+k^2}\approx\frac{(n-1)^2}{(n+1)^2}$$

($n\sim3.5, k\sim10^{-3}$)

Independent of thickness and k

$$\sigma_n=\frac{\sigma_R}{\frac{\delta R}{\delta n}}=\sigma_R\frac{(n+1)^3}{4(n-1)}\approx 10\,\sigma_R$$



Example of a fit using above formula: