New Adhesives for the future ATLAS strip detector

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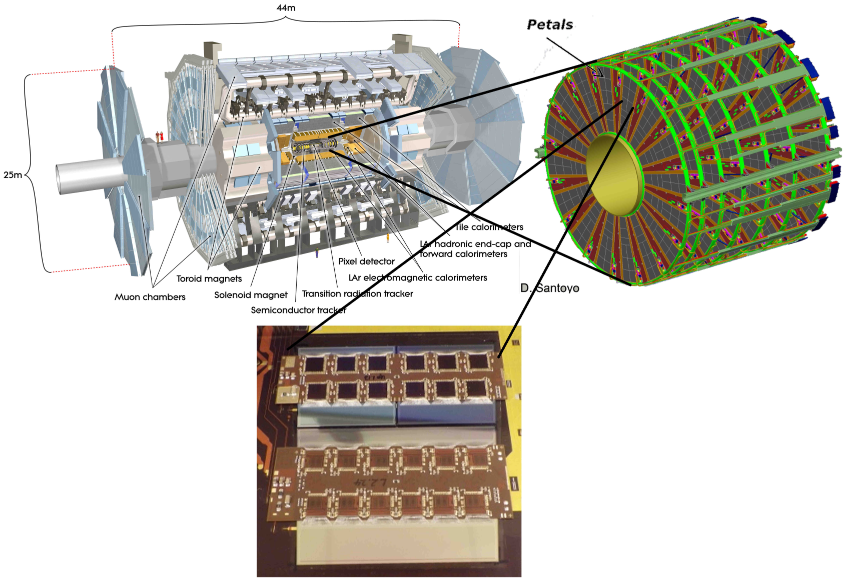
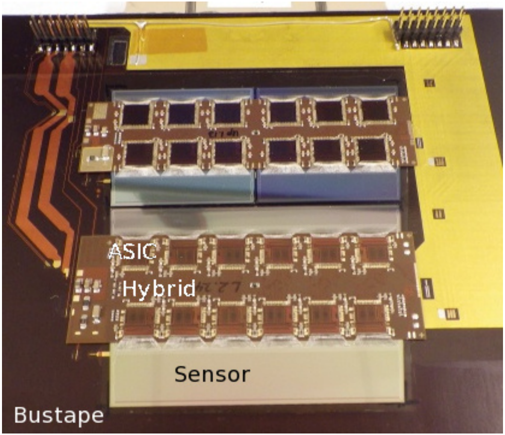
ATLAS Detector Upgrade



Where glue is used in modules (current defaults)



- ASIC → Hybrid (silver filled epoxy, TRA-DUCT 2902)
  - electrical cunductivity → legacy
- Hybrid → Sensor (unfilled epoxy, Fuller Epolite FH-5313)
- Sensor → Bustape (Al_2O_3 filled silicone gel, SE4445)

Room for improvement

- $O(12\,\mathrm{h})$ curing time for all baseline glues

TRA-DUCT 2902
ASIC $\rightarrow$ Hybrid

two-component glue

- 70-90 % (mass) silver
  $\rightarrow$ short radiation length X_0
  $\rightarrow$ high activatability
  $\rightarrow$ corrodes less noble metals

$\rightarrow$ avoided by organic glue

EPOLITE FH-5313
Hybrid $\rightarrow$ Sensor

two-component glue

- viscosity depends on time passed after mixing
- very brittle after curing

SE4445
Sensor $\rightarrow$ Bustape

two-component glue

- needs to be degased

Attacking most pressing problem: time

- Work mostly done on first step: ASIC $\rightarrow$ Hybrid glue

Money

- high number of tools + space

Increased temperatures

- stick with the baseline glue
- use same application method
- add heater to setup
- determine new curing time/temperature
  - $O(2\,\mathrm{h})$
- Challenge: maintain precision during thermal expansion

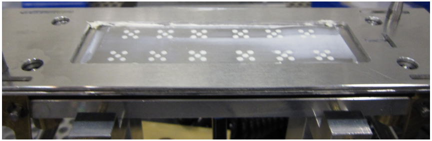
Using UV curable glue

- select new type of glue
- find new glue application method
- add UV lightsource to setup
- determine new curing time
  - $O(10\,\mathrm{min})$
- check radiation hardness, thermal/electrical/mechanical properties of new glue

Glue Application

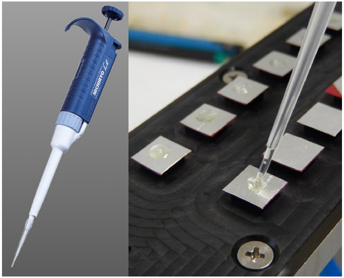
Increased temperatures

- high viscosity glue
- application with stencil
- time consuming cleaning for every hybrid



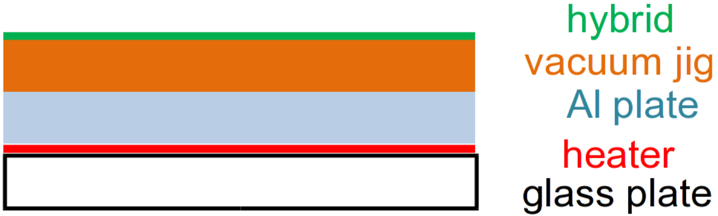
Using UV curable glue

- low viscosity
- application with μl pipette
- disposable tips $\rightarrow$ no cleaning



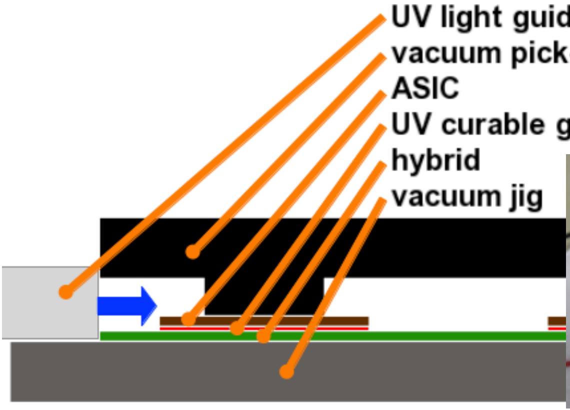
- Best solution for both: glue dispensing robot

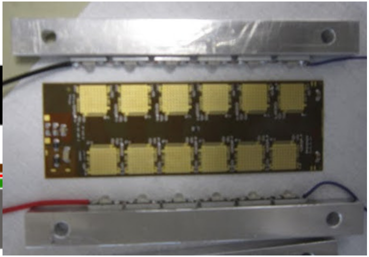
Increased temperature curing (ASIC $\rightarrow$ Hybrid)



- a stack from glass plate + heater + aluminium plate below normal cluing setup
- heat to $\sim 35\,^{\circ}\mathrm{C}$
- after $\sim 2\,\mathrm{h}$ glue cured to a point where it can support ASICs

UV curing in current setup (ASIC $\rightarrow$ Hybrid)

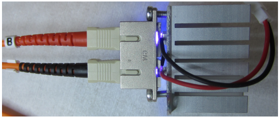
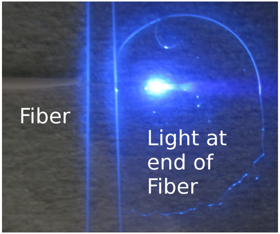




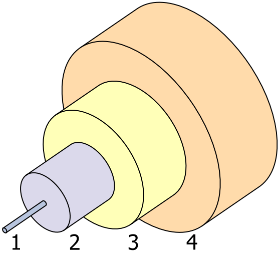
- default setup + UV light source
- only 80 μm gap (glue layer, red) available to shine in UV light
- UV glue under ASICs can be cured completely in $O(10\,\mathrm{min})$

Fiber curing Setup (Module $\rightarrow$ Bustape)

- for places not reachable from edge
- the same high power UV LEDs are used
- light is coupled into fiber by pressing connector onto LED (they have a flexible dome made from silicone)
- one LED per connector / fiber
- jacket and buffer needs to be stripped off to get to a 125 $\mu\mathrm{m}$ fiber

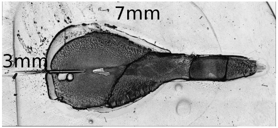



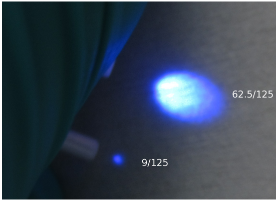
1. core ($\varnothing = 9 - 62.5\,\mu\mathrm{m}$ glass)
2. cladding ($\varnothing = 125\,\mu\mathrm{m}$ glass)
3. buffer ($\varnothing = 250\,\mu\mathrm{m}$ plastic)
4. jacket ($\varnothing = O(1\,\mathrm{mm})$ plastic)

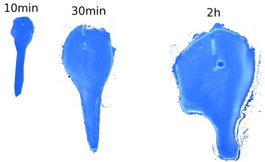


Fiber curing Tests (Module → Bustape)

- so far only tests with PVC foils done
- 125 μm spacing (pieces of fiber as spacers)
- after curing
  - separate foils
  - remove uncored glue
  - check amount of cured glue
- test whether light is actually conducted in core and not in the cladding
  - → light is conducted in core
  - → bigger core = more light
- longer times cures more glue and stronger







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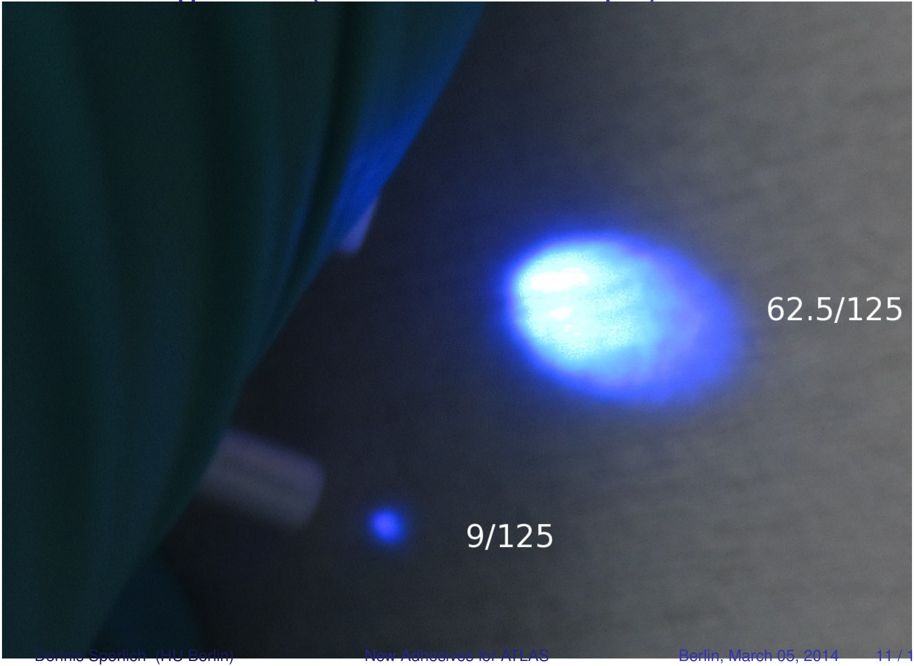

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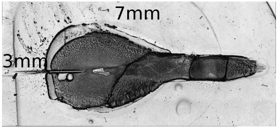
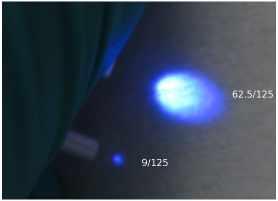
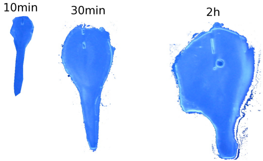
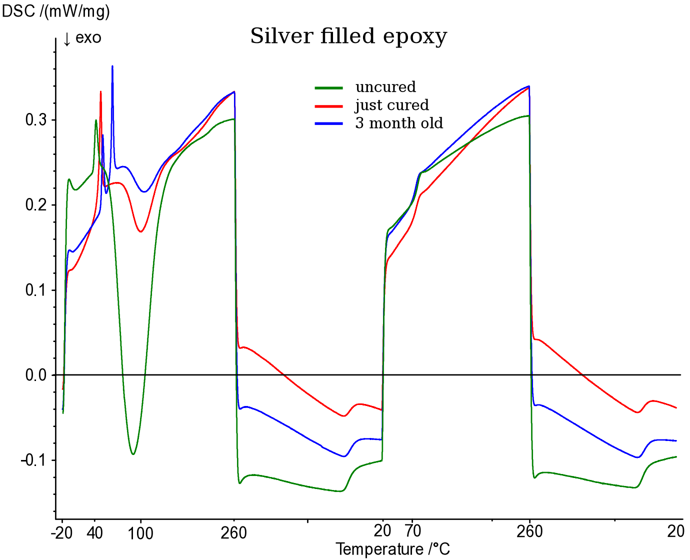




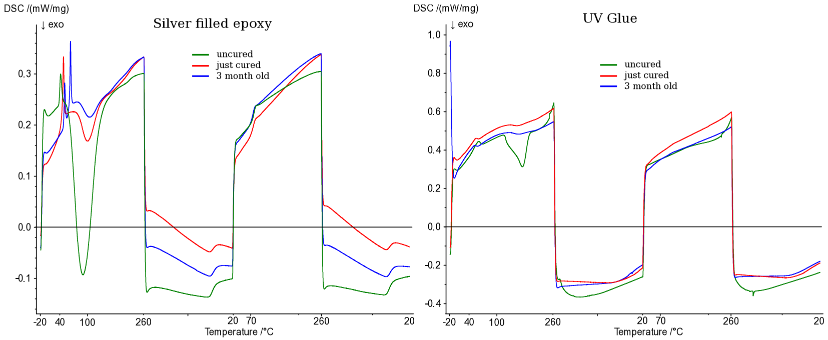


Thermal behaviour of glue



- several glues measured with differential scanning calorimetry

Thermal behaviour of glue



- left plot shows still curing even after three month
- right plot (one UV glue) does not show any curing of previously cured glue
- both show glass transition temperature 60 °C – 70 °C, but for silver epoxy it is more pronounced

Conclusion

- the problem of reducing the modul production time / (# of tools) was approached with heat accelerated curing and UV curing glues
- UV curing has several advantages:
  - faster, even than heat accelerated curing
  - less cleaning (manual work = time)
  - less material in detector
  - cheaper glue
- many questions of UV glue are resolved (see Luise's talk from last year)
  - curing
  - radiation hardness
  - thermal cycling
  - shear strength
  - ...
- no show stopper for use in ATLAS detector