Optical characterization and irradiation tests on silicon resins and WLS at ENEA Calliope lab

Stefania Baccaro, Alessia Cemmi, Salvatore Fiore, Marco Montecchi

ITALIAN NATIONAL AGENCY FOR NEW TECHNOLOGIES,
ENERGY AND SUSTAINABLE ECONOMIC DEVELOPMENT
Research Centre Casaccia
(Rome, Italy)

Outline

- **Optical coupling materials** *(Momentive, USA)*

  - two-component silicon resin (RTV 615, TSE 3032)

  …before and after irradiation (up to 30 Gy)…

- **Wavelength shifter** *(Eljen Technology, USA)*

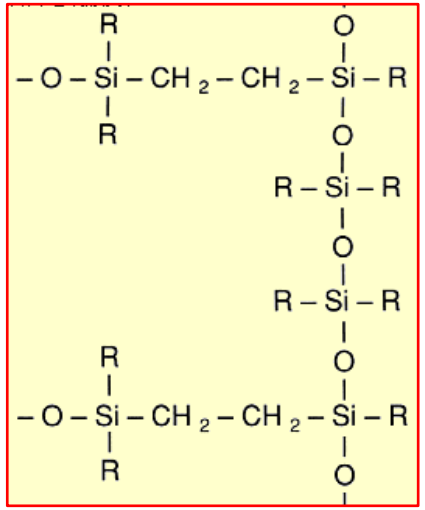
  - blue waveshifting paint (EJ-298#2)

  - wavelenght shifter near-UV to blue (EJ-299-27)

  …before irradiation…

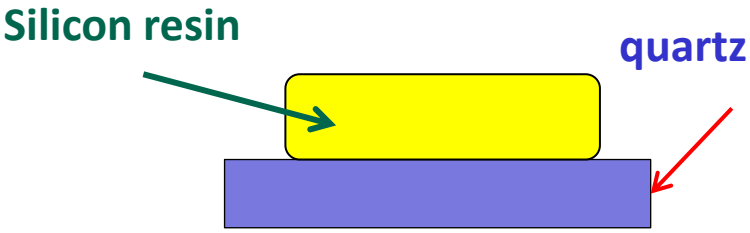
Optical coupling materials: two-component silicon resins

RTV 615 and TSE 3032



Refractive Index : 1.406

Low viscosity, transparent silicon rubber designed for protection of electronic components and assemblies against shock, vibration, moisture, ozone, dust, chemicals, and other environmental hazards by potting or encapsulation of the components and assemblies.



- ✓ different thickness (1mm; 2mm)
- ✓ transparent, not rigid

Optical characterization: Transmittance measurements and irradiation tests

Transmittance curves
Range: 200-800 nm
UV-VIS spectrometer Lambda 950 (Perkin-Elmer)

… before irr…

- ✓ **spectrum shape *(different materials)***
- ✓ **thickness effect on transmittance**
- ✓ **Transmittance @ 315 nm**

***Dose rate*: 5 Gy_{air}/h**

***Total absorbed doses*: up to 30 Gy**

in air, at RT

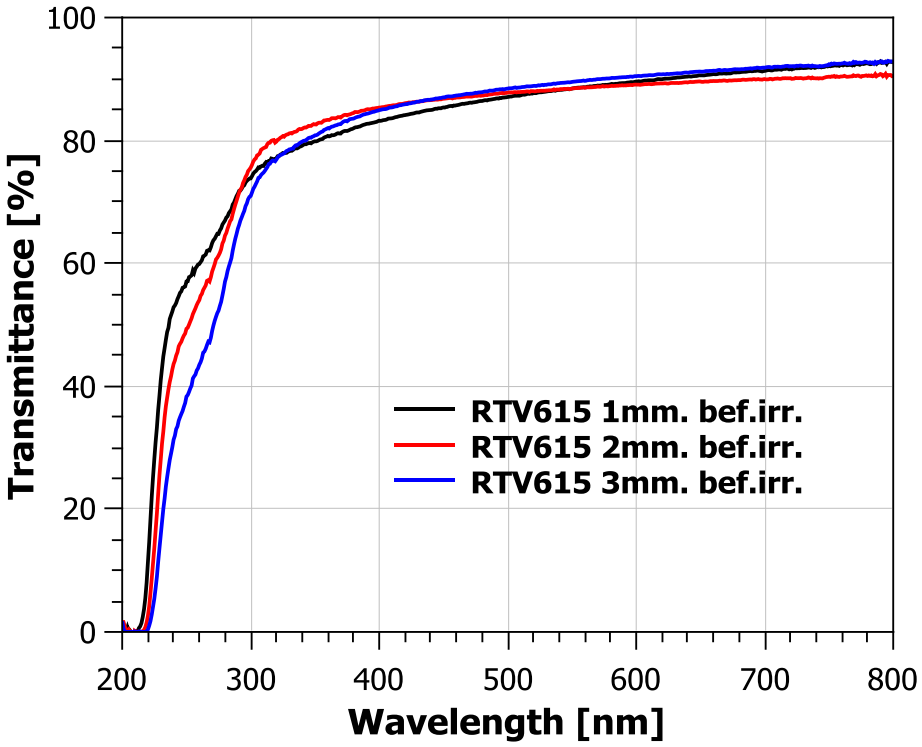
… after irradiation…

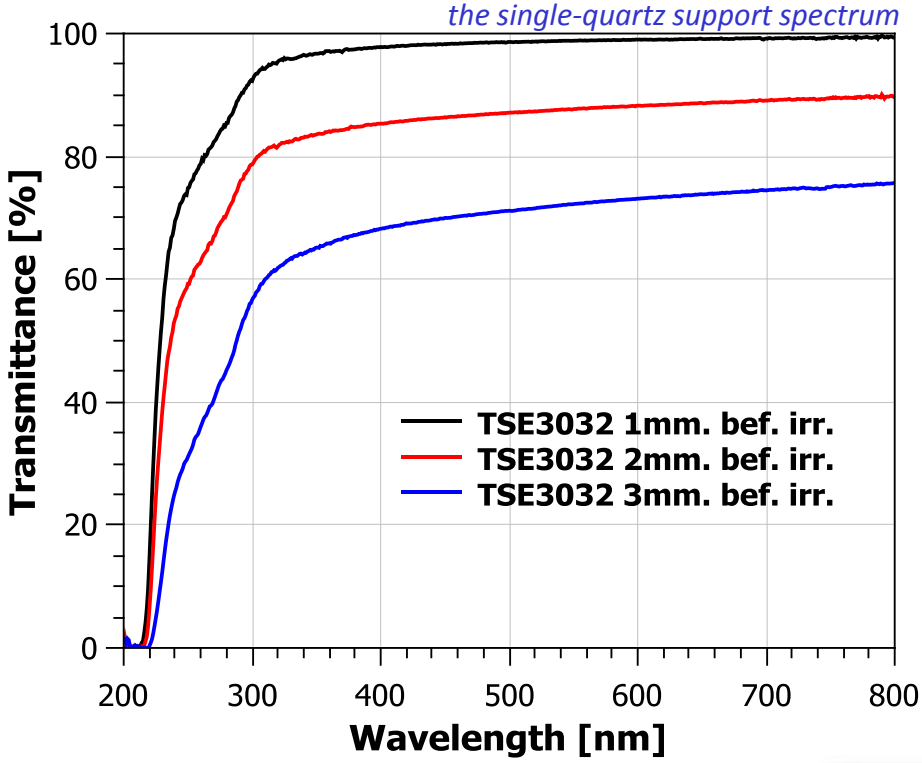
- ✓ **gamma irradiation effect**
- ✓ **stability after the end of irradiation**

Silicon resins before irradiation: thickness effect

%T error = ± 1%

Transmittance curves normalized by the single-quartz support spectrum





- ✓ ***RTV615: more stable***
- ✓ ***TSE3032: thickness sensitive***

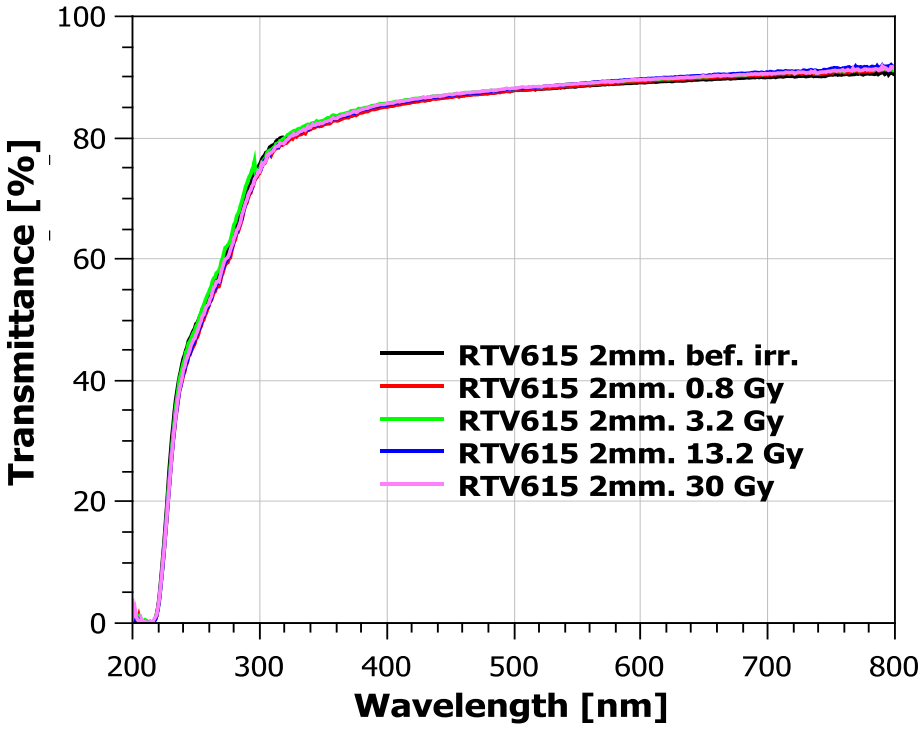
Thickness [mm]	Transmittance @ 315nm [%]	
	RTV615	TSE3032
1	76.62	94.96
2	79.63	81.51
3	76.21	61.15

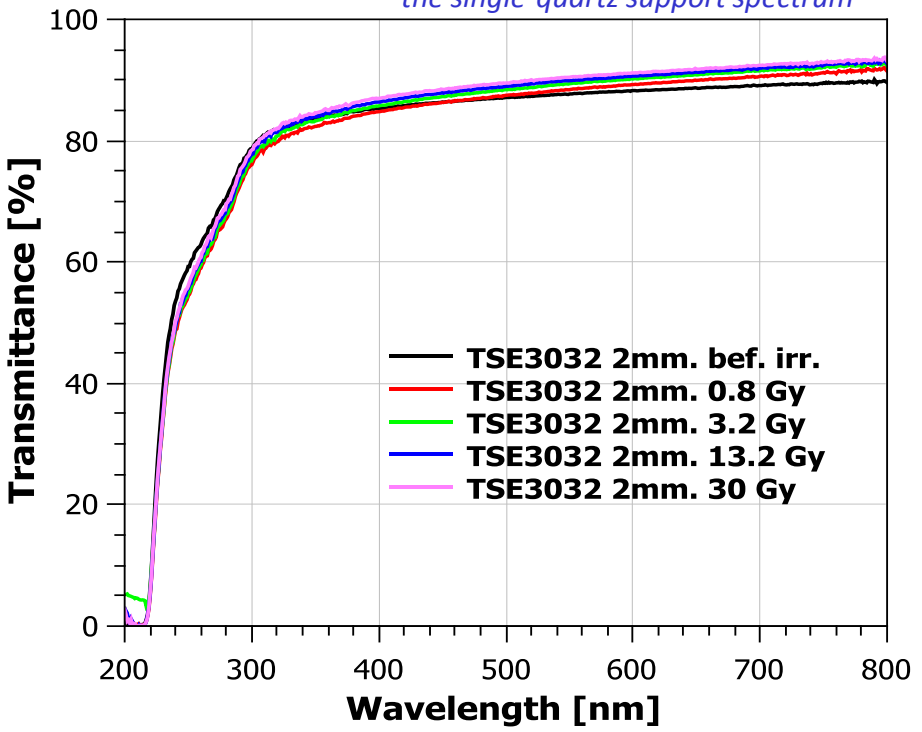
BC630 (1mm)	Epo-tek 301 (770 micron)
81.90	30.00

Silicon resins after irradiation: abs. doses up to 30 Gy

%T error = ± 1%

Transmittance curves normalized by the single-quartz support spectrum





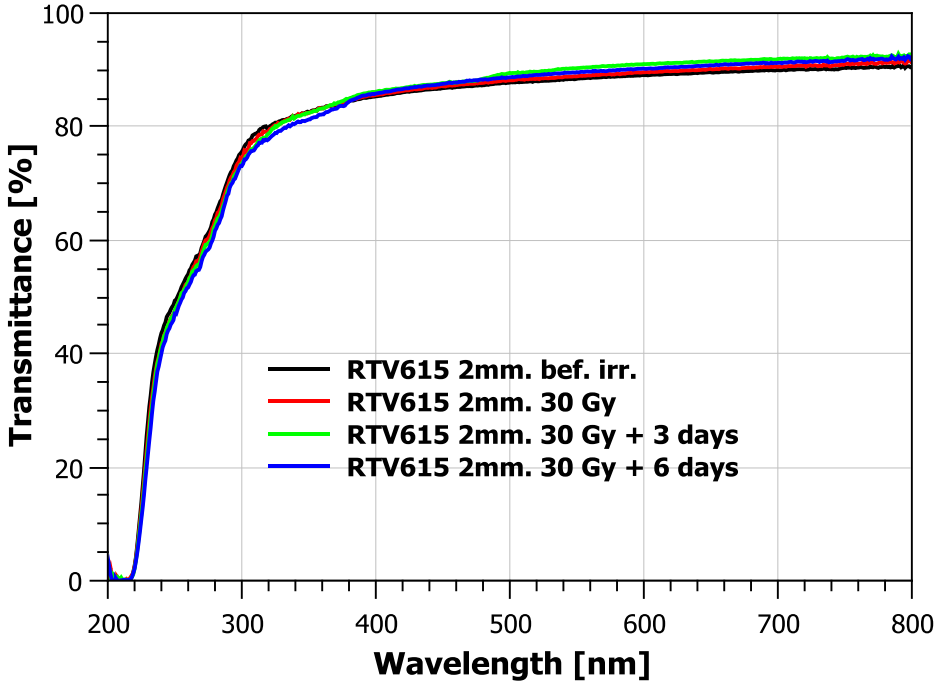
RTV615 and TSE3032:
not modified by gamma irradiation (up to 30 Gy)

Absorbed dose [Gy]	Transmittance @ 315nm [%]	
	RTV615	TSE3032
0	79.63	81.51
13.2	78.55	79.97
30	78.61	81.30

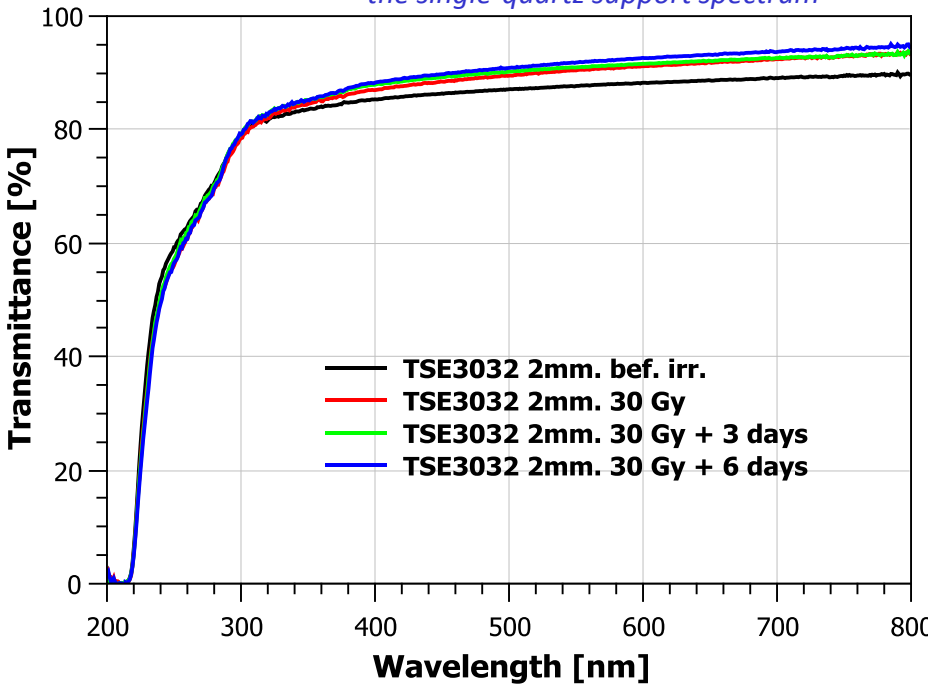
BC630 (1mm)	Epo-tek 301 (770 micron)
81.90	30.00
80.60	30.60

Stability after irradiation (30 Gy) of silicon resins

%T error = ± 1%



Transmittance curves normalized by the single-quartz support spectrum



✓ ***RTV615 and TSE3032: negligible changes after the end of irradiation (30 Gy)***

Time after the end of irradiation [days]	Transmittance @ 315nm [%]	
	RTV615	TSE3032
0	79.63	81.51
3	77.58	82.20
6	77.16	82.00

Wavelength shifter (Eljen Technology, USA)

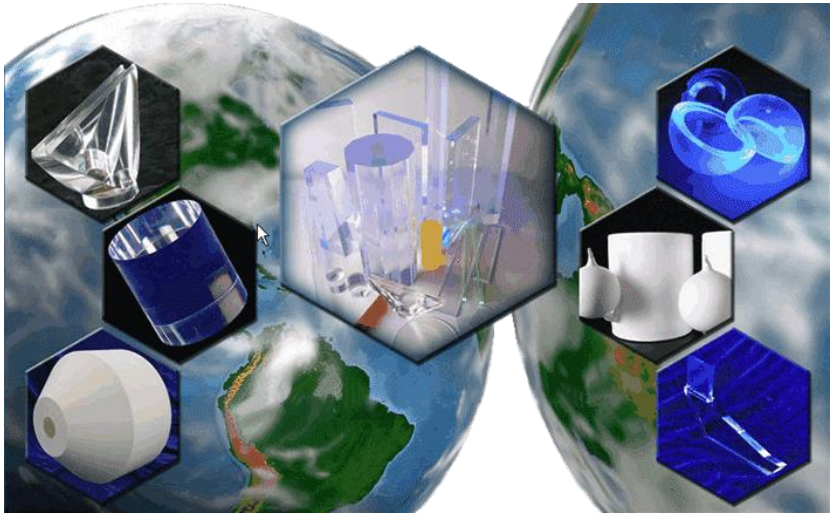
EJ-298#2

BLUE WAVESHIFTING PAINT

polyvinyltoluene binder and fluorescent dopant in xylene solvent (20%wt)

50 micron thickness:

quantum efficiency	> 90%
decay time	2.0 ns
emission maximum	434 nm



EJ-299-27

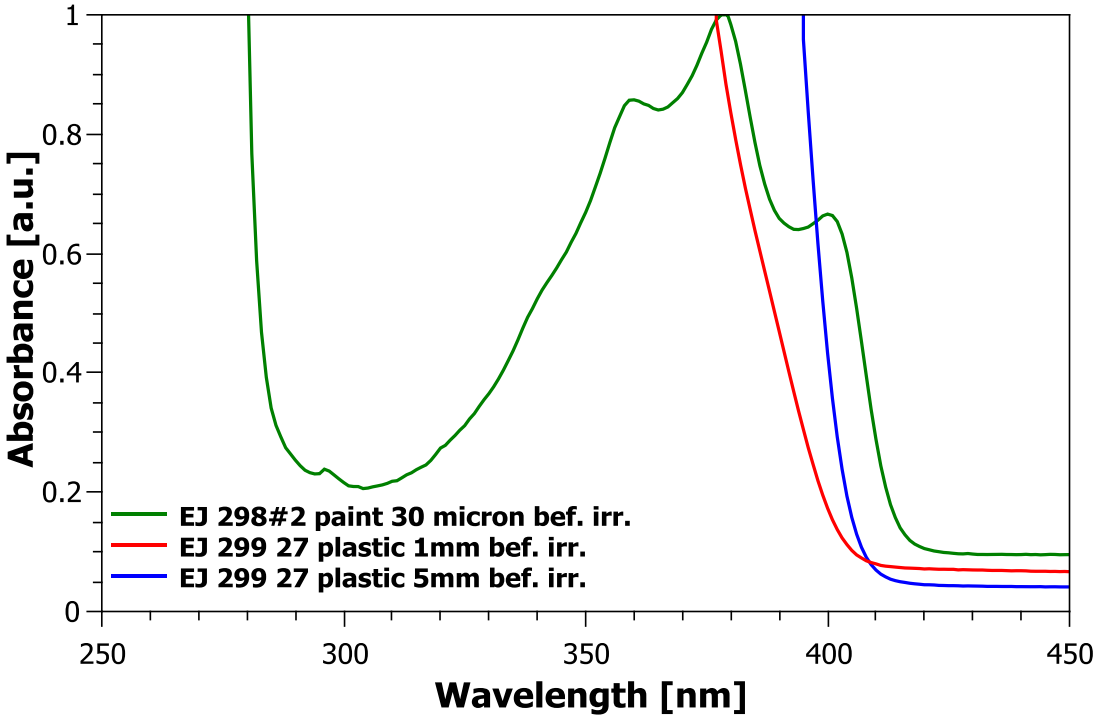
WAVELENGTH SHIFTER NEAR-UV TO BLUE PLASTIC

polyvinyltoluene plastic and fluorescent dopant

5 mm thickness:

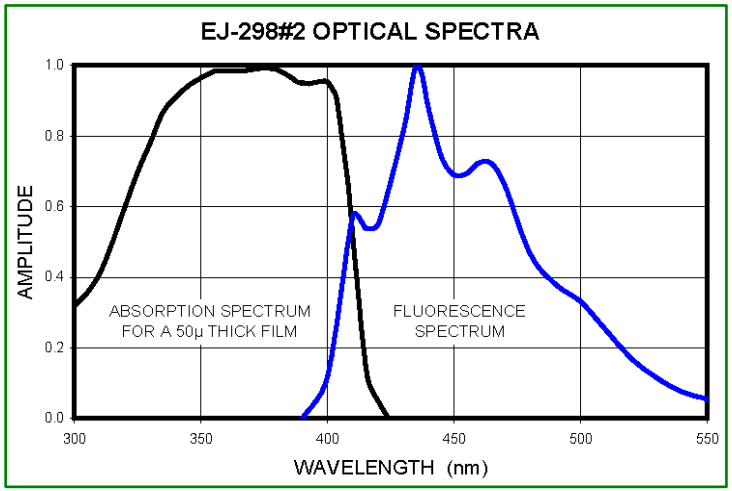
quantum efficiency	92%
decay time	1.2 ns
emission maximum	425 nm

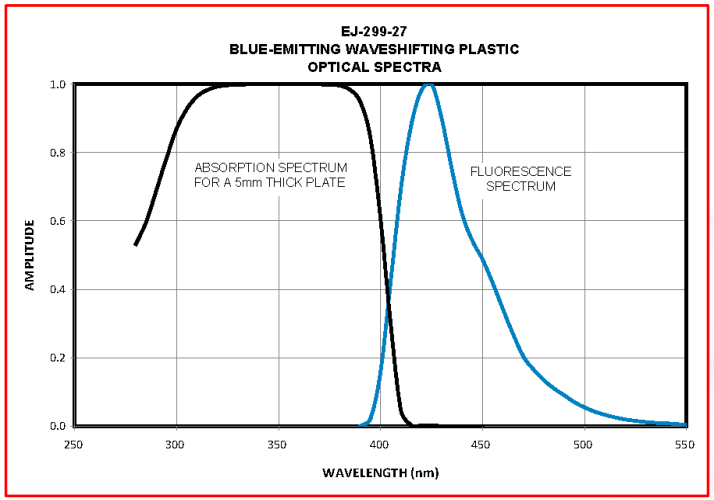
Wavelength shifter: optical characterization before irr.



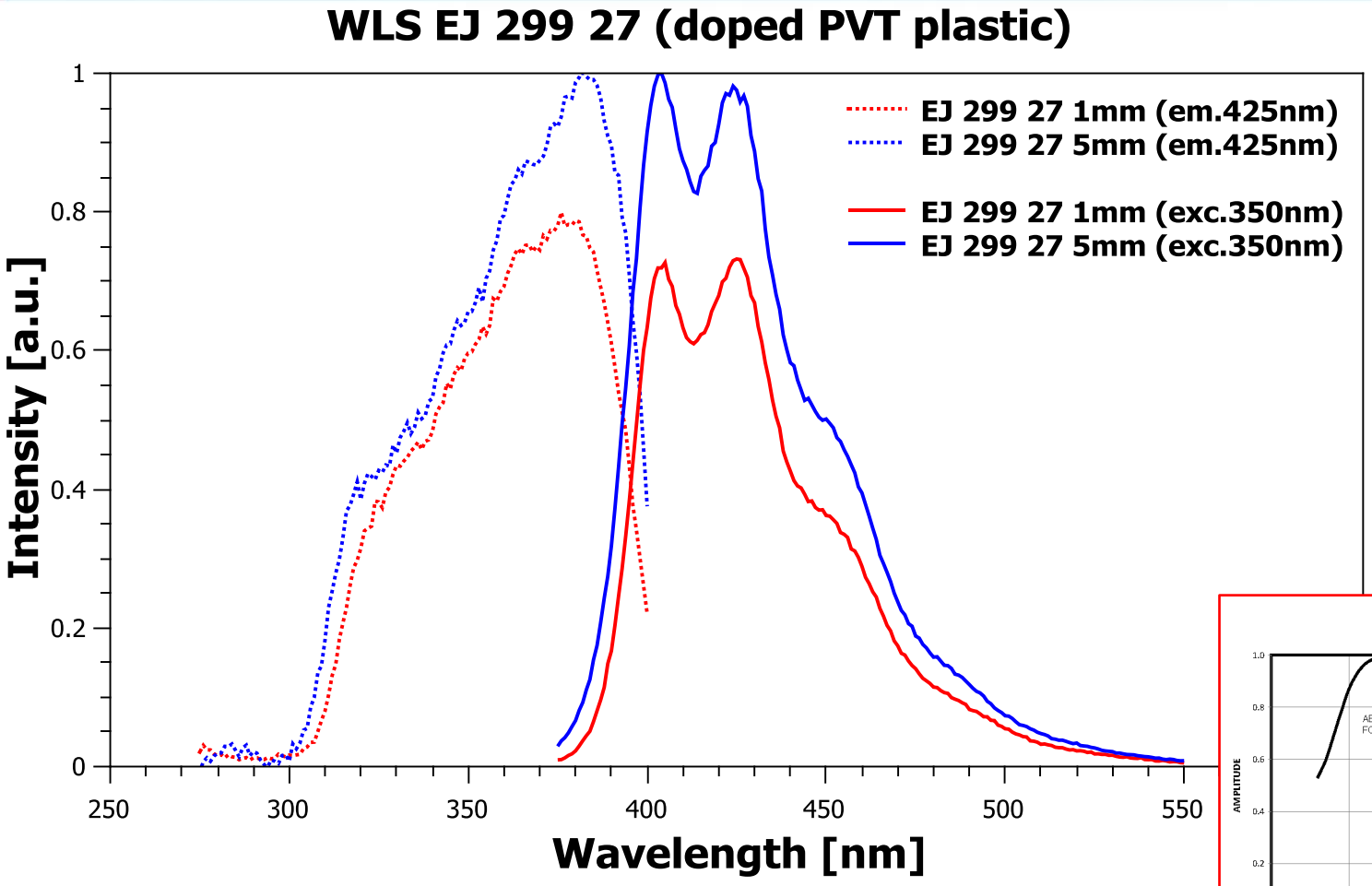
✓ **EJ 298#2 paint**: ***Abs. curve similar to data sheet***

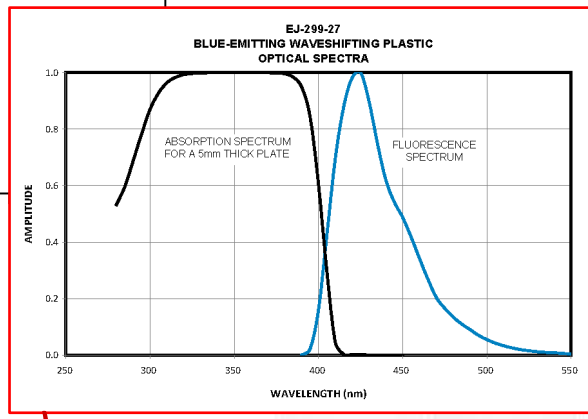
✓**EJ 299 27 plastic**: ***very high absorption in the near-UV range*** *(more than expected)*





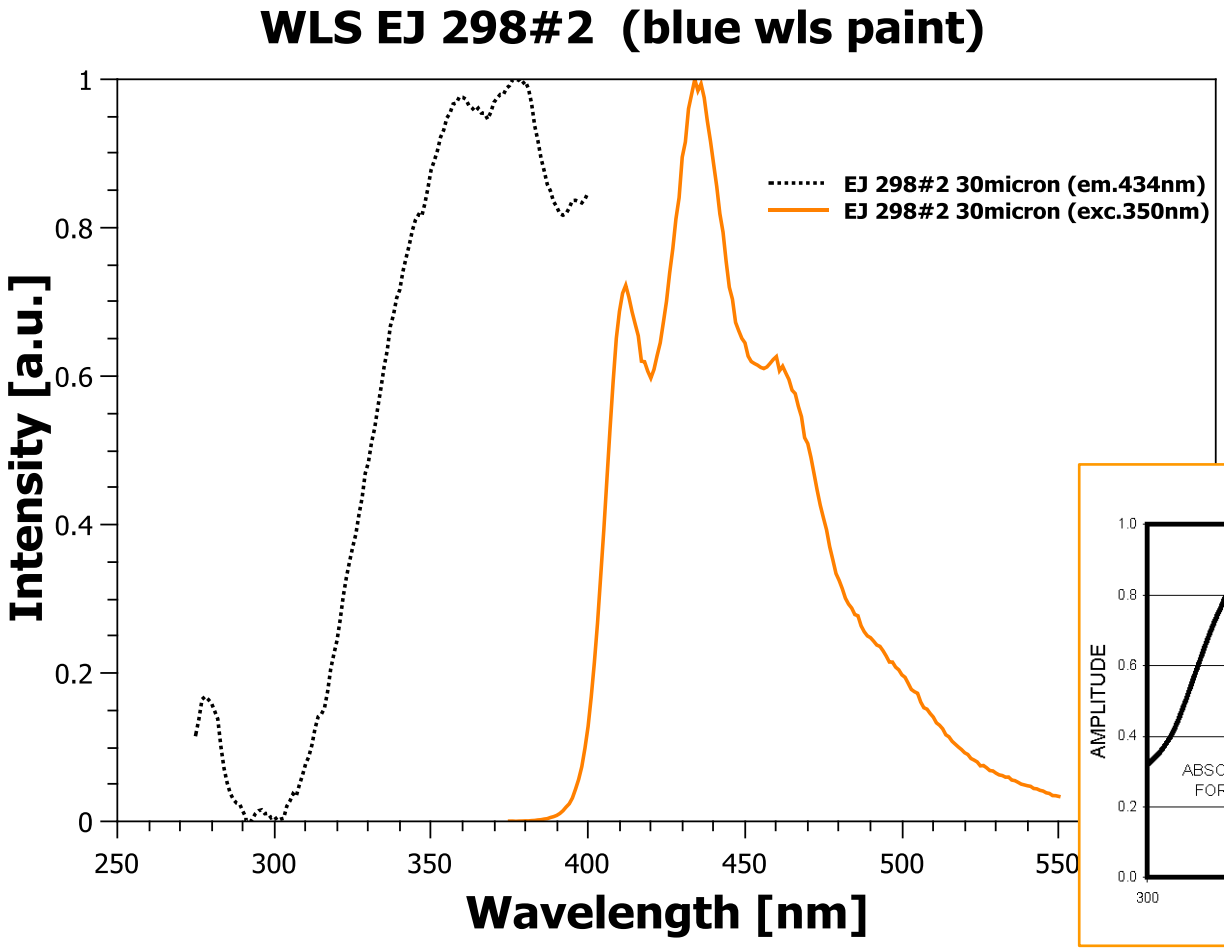
Plastic WLS : excitation/emission spectra bef. irr.

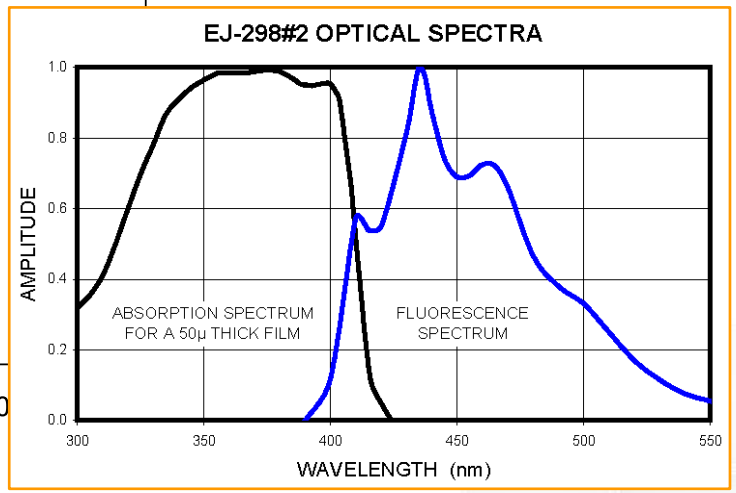




- ✓ 1 mm and 5 mm: same spectra *(different intensities)*
- ✓ excitation maximum at around 380 nm

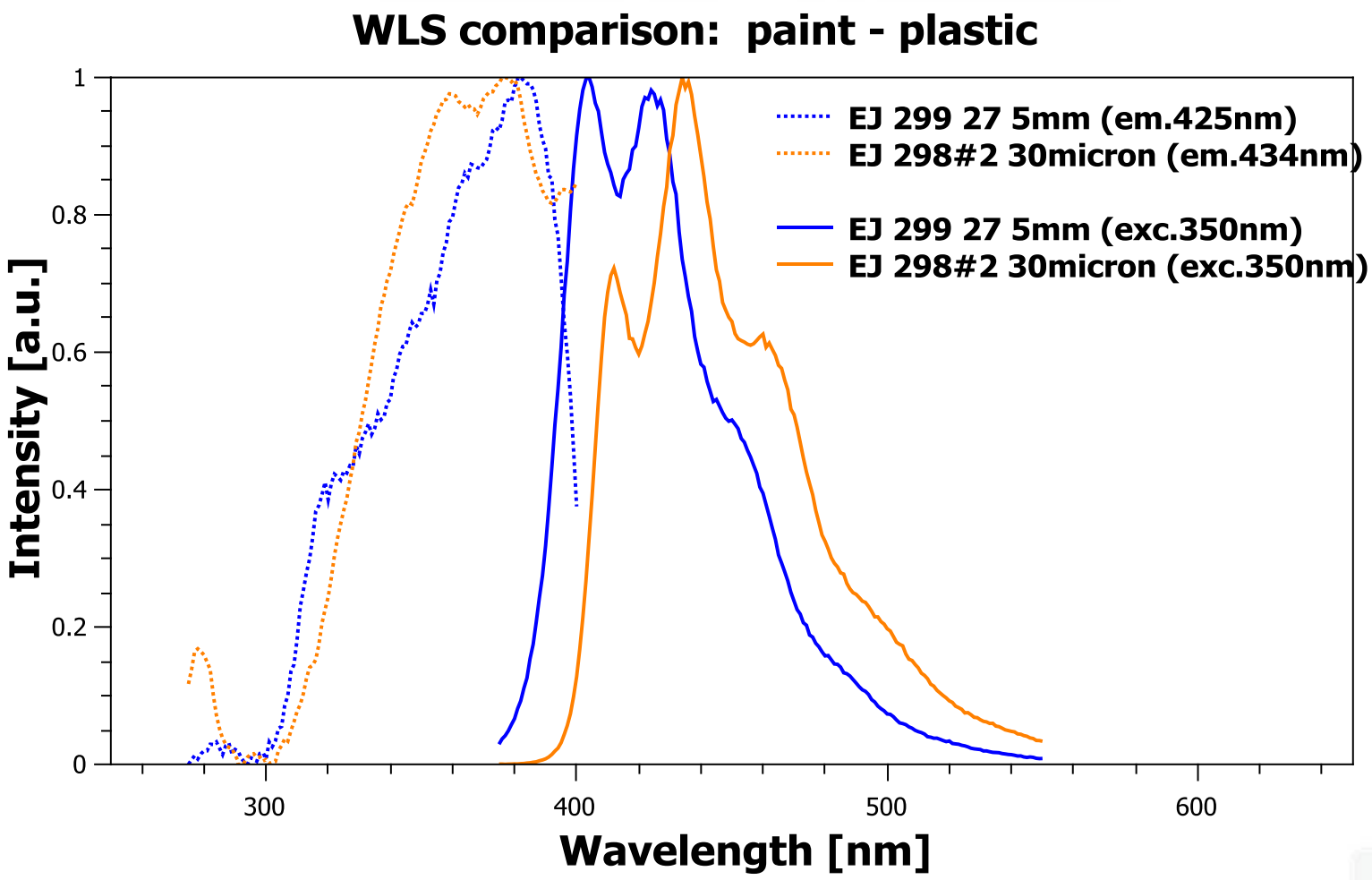
Paint WLS : excitation/emission spectra bef. irr.





✓ excitation maximum in the range 360-380 nm

Plastic vs paint WLS : excitation/emission spectra bef. irr.



✓ Intensity (exc. spectra) @ 315 nm:

EJ 298#2 paint 0.15

EJ 299 27 plastic 0.38

Conclusions :

- **Two-component silicon resins:**

  - RTV615 less dependent on the thickness (differently from TSE 3032)
  - good transmittance @315 nm *(before and after irradiation)*
  - higher gamma irradiation resistance (up to 30 Gy) and stability
  - not rigid, mechanically stable *(self-standing)*

- **Wavelength shifter:**

  - EJ-298#2 paint and EJ-299-27 plastic (1mm, 5mm)
  - EJ-299-27 plastic: too high absorption in the near-UV range (< 370nm)
  - excitation spectra: low absorption @315 nm *(paint: 0.15 ; plastic: 0.38)*
  - excitation maximum at longer wavelentgh (> 350 nm)

…further work…:

- **Crystals irradiation and optical characterization** (transversal and longitudinal transmittance)

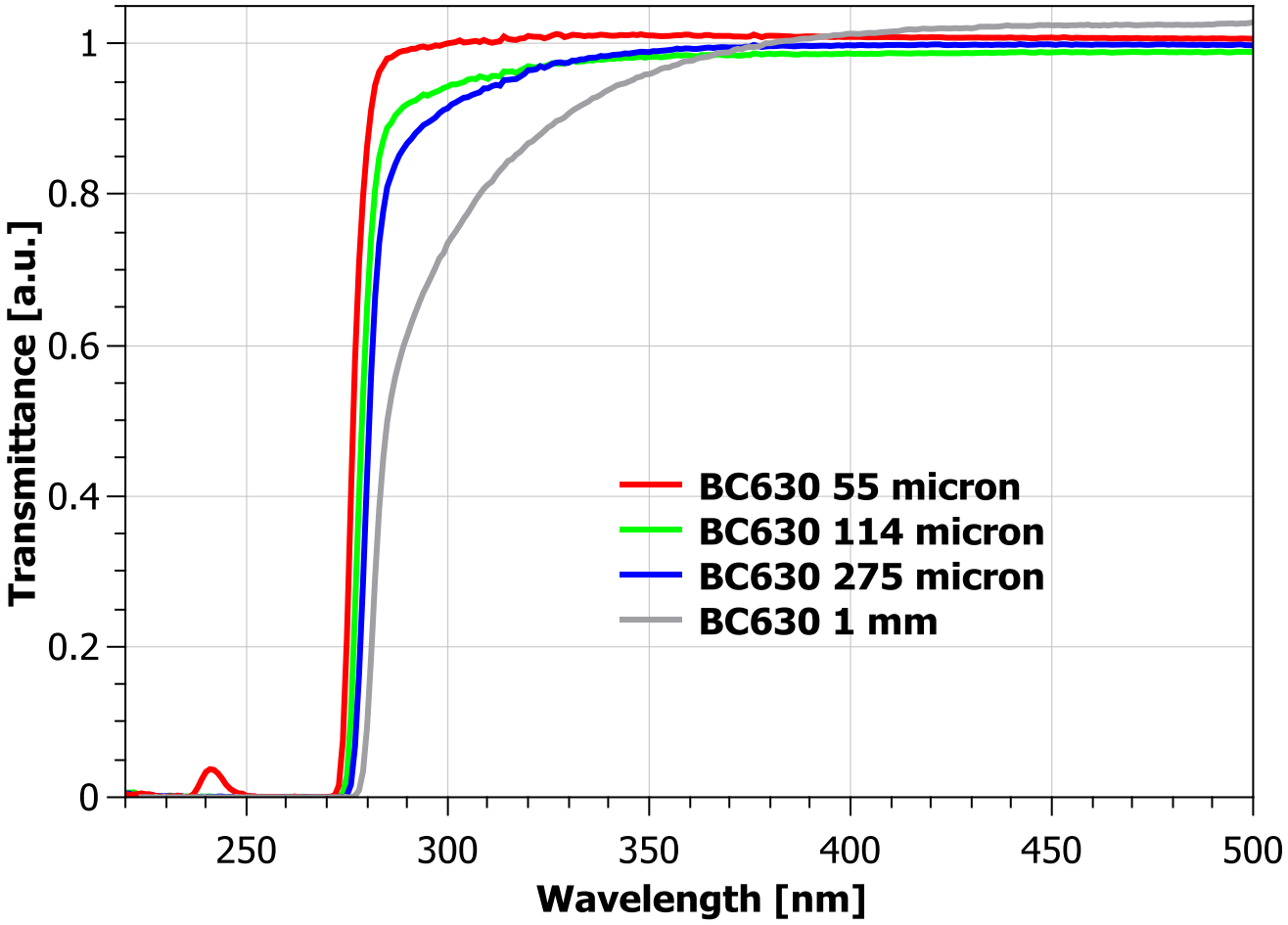
- **Silicon resins:**
  stability study during time (after irradiation)
  irradiation at higher absorbed doses

- **Wavelength shifter**:
  EJ-298#2 paint and EJ-299-27 plastic : ***….best choice…?***
  irradiation and characterization

THANK YOU
FOR
YOUR ATTENTION

alessia.cemmi@enea.it

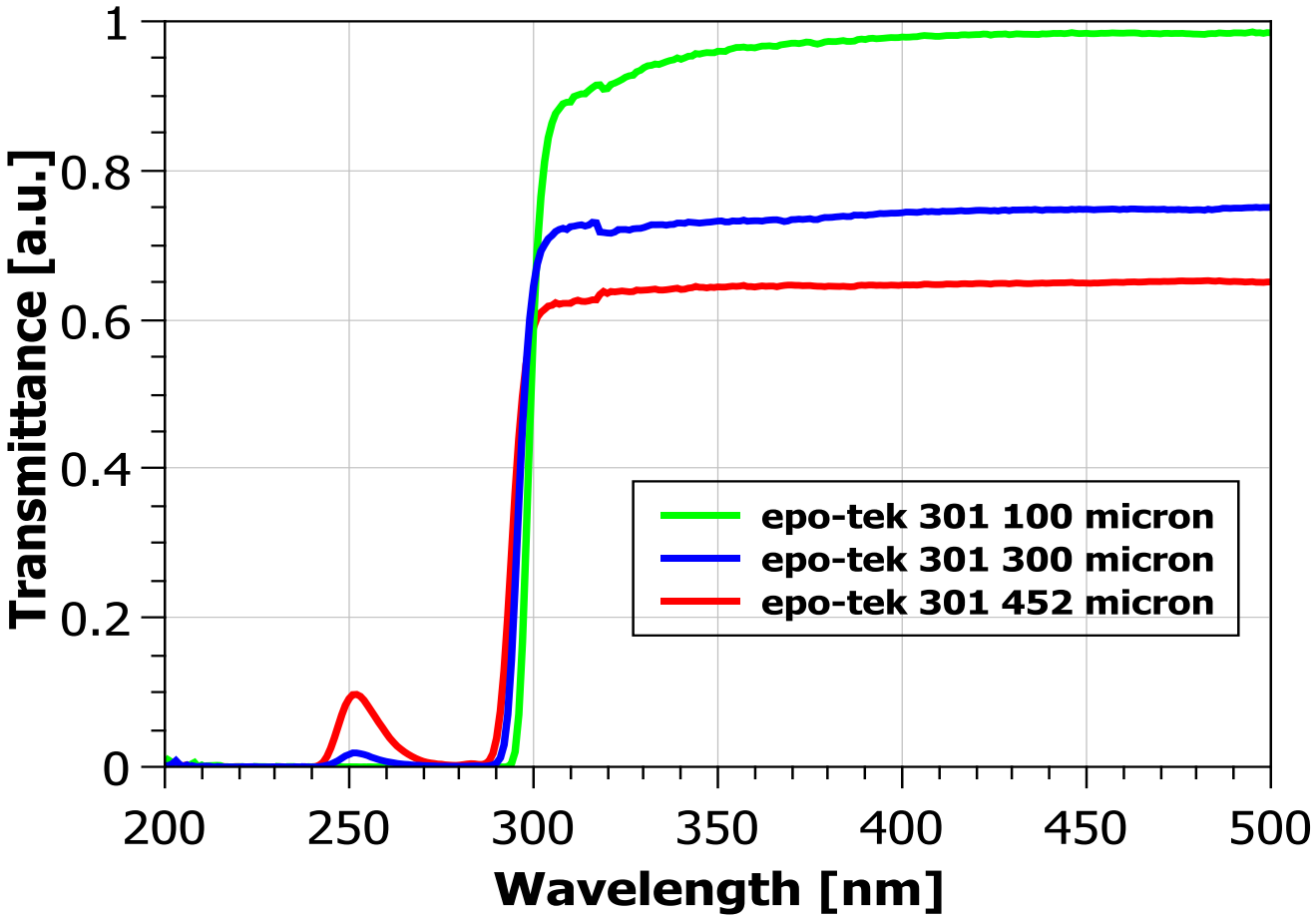
Materials before irradiation: BC630 grease



Transmittance curves normalized by the single- quartz support spectrum

- **Abrupt transmittance drop in the UV range *(270-280nm)***
- **High Transmittance *(dependent on the sample thickness)***

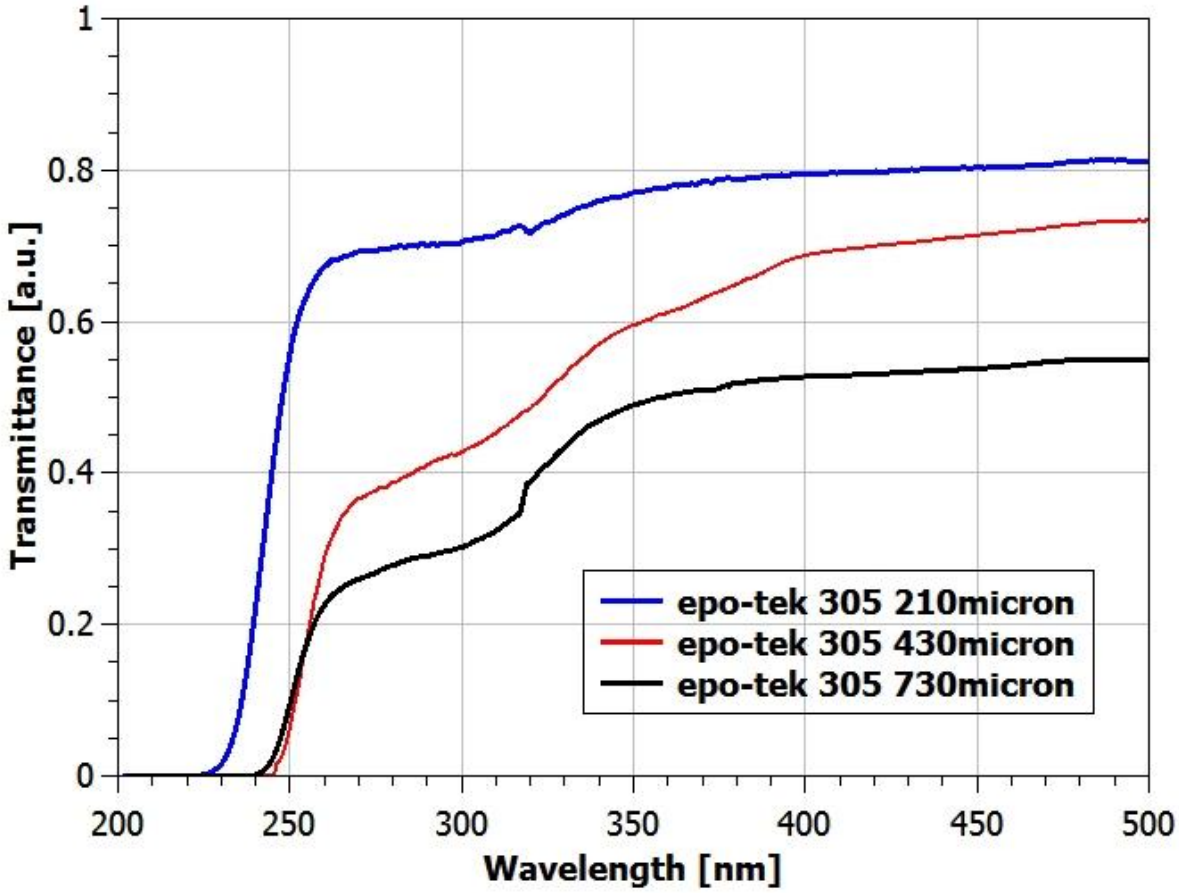
Materials before irradiation: Epo-tek 301 resin



Transmittance curves normalized by the single-quartz support spectrum

- **Transmittance drops at around 300nm *(UV range)***
- **Transmittance depends on the sample thickness *(thin layer: very good results)***

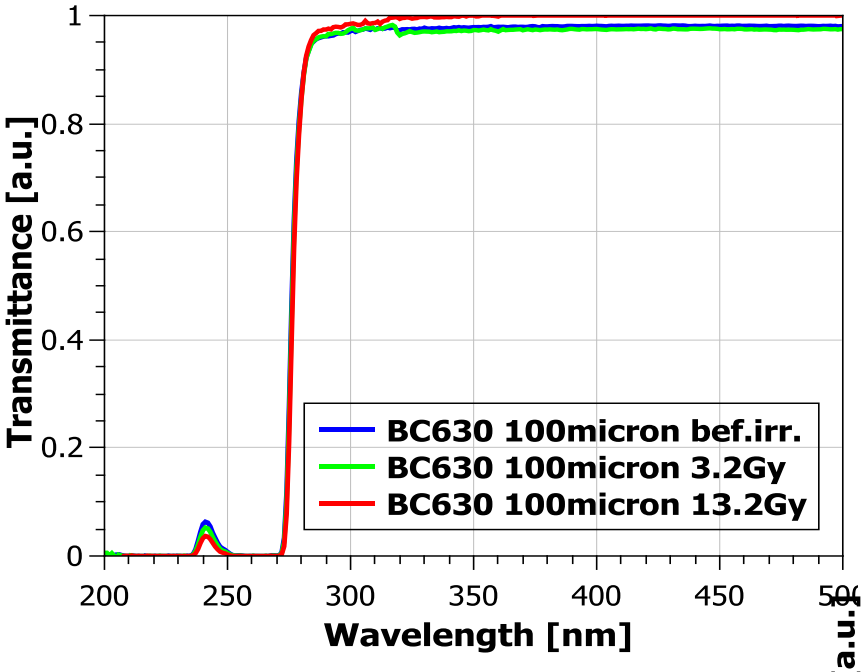
Materials before irradiation: Epo-tek 305 resin



Transmittance curves normalized by the single- quartz support spectrum

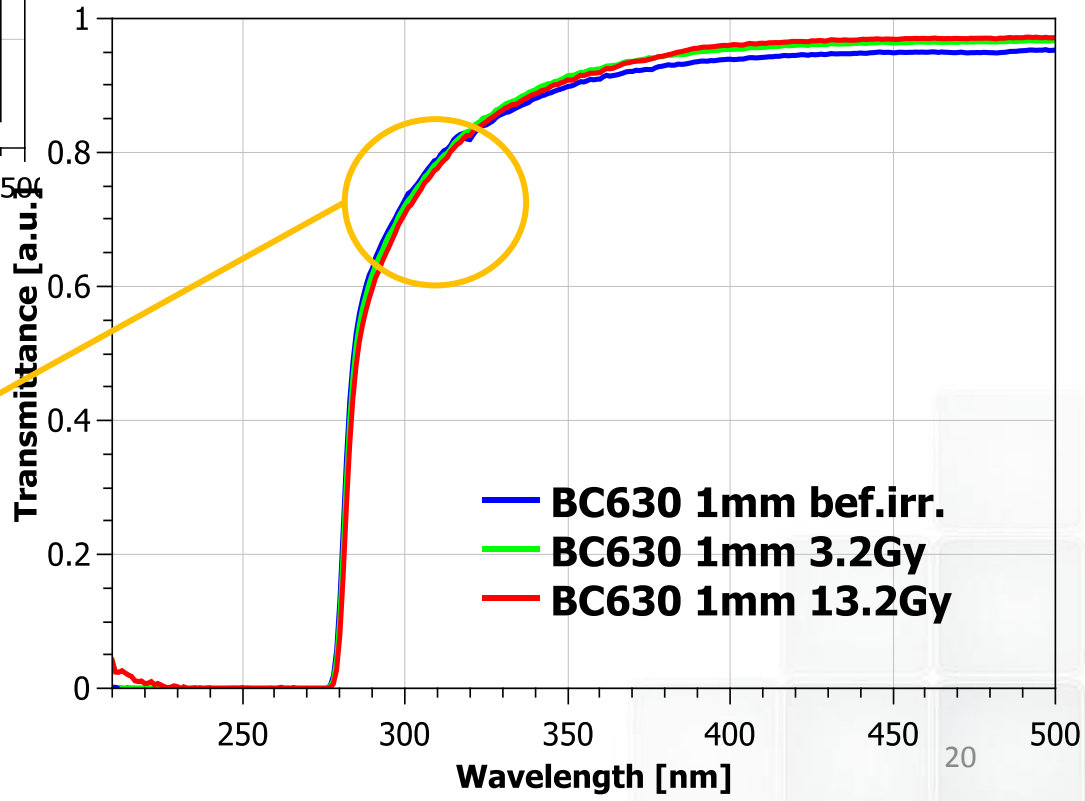
- **Partial transmittance in the UV range**
- **Significant decrease of transmittance and different spectrum shape *(sample thickness)***

Materials after irradiation: BC630 grease

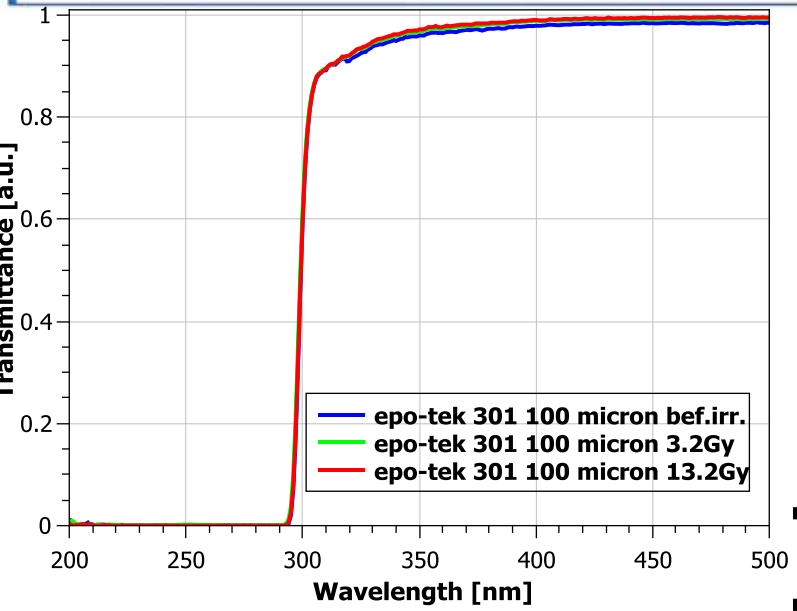


✓ high radiation hardness
at lower and higher thickness

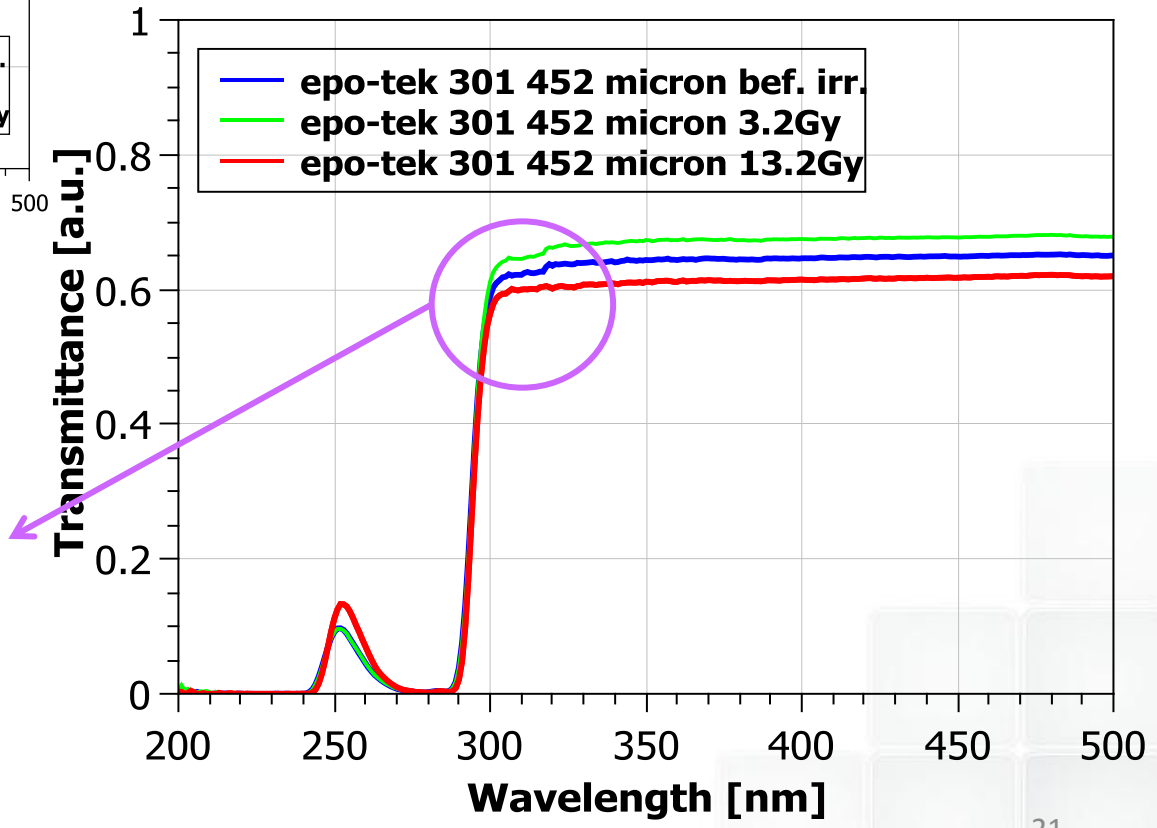
Transmittance @ 315nm [a.u.]		
Bef.irr.	3.2Gy	13.2Gy
0.82	0.81	0.80



Materials after irradiation: Epo-tek 301 resin



✓ changes under irradiation more evident with the increase of the thickness



Transmittance @ 315nm [a.u.]		
Bef.irr.	3.2Gy	13.2Gy
0.62	0.65	0.60