Production process and characterization of sensitized all elastomeric POF

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Motivation

To fulfill the demanded properties for partial discharge detection application [1] we developed the first fluorescent functionalized all-elastomeric POF[2]:

- Temperature stability up to 150°C
- High elasticity
- Transparent cladding
- High numerical aperture
- Dielectric constant close to ε = 2.73
- Control of the chemical composition of the core material
- Fiber length up to 1.8 m is possible
- The sample diameter is 2 mm (Fig. 2.)

Production process

- Cladding: The Thickness of 100-150 µm is set by tuning the viscosity and curing properties of the liquid two-component resin.
- Cladding-core interface: A high quality interface is formed driven by surface tension .
- Core material: For our proposes[2] a polysiloxane functionalized with a fluorescent dye is inserted and cured at elevated temperature, leading to a stable covalent linkage of core and cladding (Fig. 1.).

Optical quality and characteristics

Depend on

- Intrinsic material attenuation, dust and remaining gas
- The boundary quality between core and cladding (Fig. 3.a): low roughness of R_a = 3.3 nm
- Spectral properties of the dye
  - Absorption spectra
  - Emission spectra
  - Reabsorption (Fig. 4 a-b)

The resulting fiber attenuation of the green fluorescent dye doped sample (Fig. 2.) is now

α = 5.1 dB m^{-1} (Fig. 3.b)

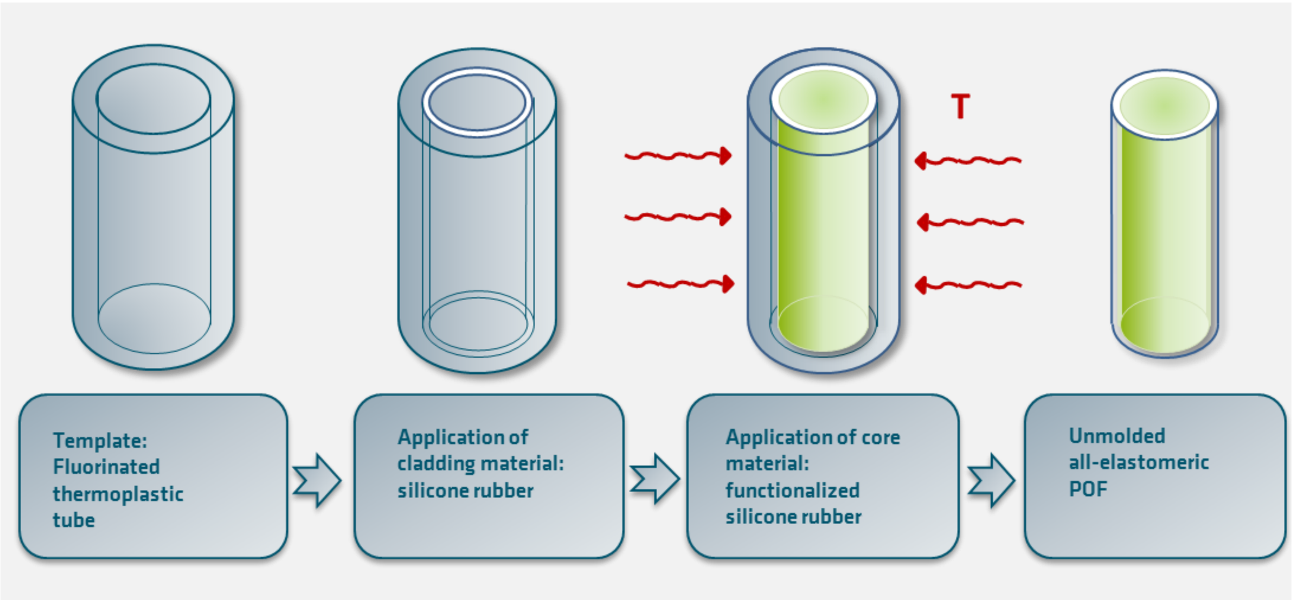

Fig. 1. Process steps of all elastomeric POF production

Fig. 2. green fluorescent silicone step-index E-POF with an outer diameter of 2 mm

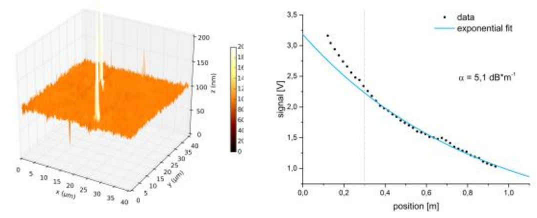

Fig. 3. a) atomic force microscope image of the cladding-core interface
b) measurement of fiber attenuation of a green fluorescent E-POF (integral)

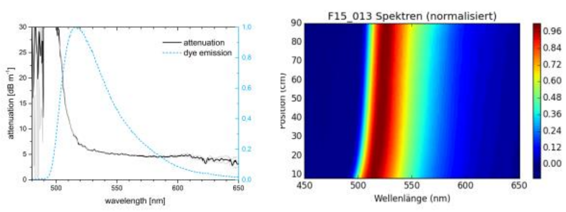

Fig. 4. The fluorescence of the core material allows to measure optical attenuation nondestructively corresponding to side-illumination fluorescence spectroscopy[3]
a) spectrally resolved attenuation measurement of the green fiber and the dye emission spectrum b) normalized detected spectra for different propagation lengths

Aging and temperature stability

A thermal aging test representative for testing cycles applied to high voltage cable accessories (Fig. 5.) has been conducted to a green fluorescent E-POF (Fig. 2.). An increase of optical loss about 1 dB m^{-1} was obtained but may be tolerated on the application.

Fiber length extension by „chemical splicing“

Concatenation of fluorescent E-POF with lower attenuation transparent E-POF can extend the range in sensing applications. No significant reduction of mechanical strength is apparent.

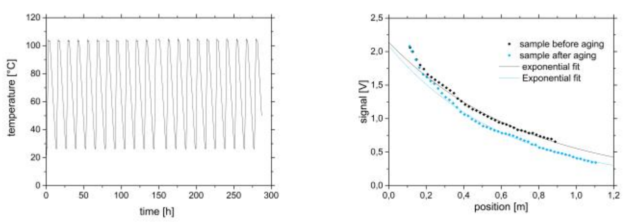

Fig.5. a) temperature profile of the aging programm; b) dataset and exponential fit of the optical attenuation measurement before and after aging

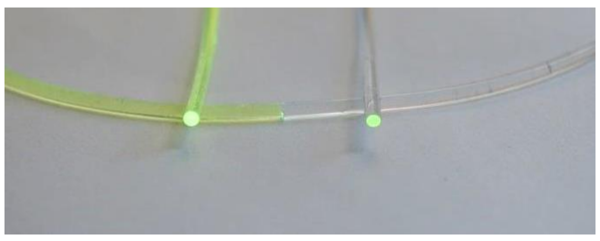

Fig.6.: „Chemically spliced“ E-POF consisting of fluorescent E-POF and transparent E-POF

References
[1] D. Siebler, M. Hohberg, P. Rohwetter, R. Brusenbach, R. Plath, Elastomeric fluorescent POF for partial discharge detection – recent progress, *OFS-24*,
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[3] R. J. Kruhlak, M. G. Kuzyk, Side-illumination fluorescence spectroscopy. II. Applications to squarainedye-doped polymer optical fibers, *J. Opt. Soc. Am. B* **1991**, 16, 1756-1767. **2015**, Curitiba, Brazil, accepted.

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