

Introduction

- Photonic Crystal Fibers (PCFs) are well suited for filling the holes with an electro-optic (EO) polymer
- Large and fast EO effect of purely electronic origin is applicable for high speed switching and modulation directly in a fiber
- Combination of low loss silica fibers with EO polymers opens way for new fiber-integrated devices

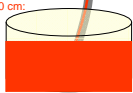
1. Filling

- Filling by capillary force into hole size of 3-7 μm
- With an over pressure of 5 bars, the filling time reduces by a factor of 10
- Typical filling length is about 10 cm
- Filling with commercially available EO polymers dissolved in solvent is possible (eg. PMMA-DR1, PS-DR1)
- New epoxy monomers with EO chromophores do not require solvent

7 μm capillary fiber filled with PS-DR1



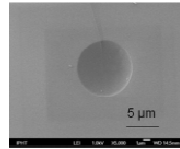
Typical filling time for 10 cm:
2 days at 1 bar
4 hrs at 5 bar



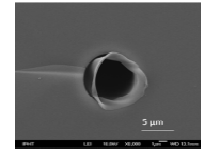
2. Curing

- Heating in the oven at 180°C to remove solvents in the case of PS-DR1
- Thermal crosslinking at 150°C in the case of Epoxy-DR1

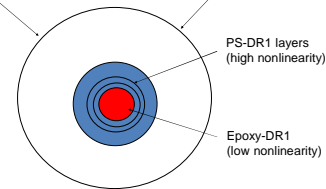
Filling material:
Epoxy-DR1 without solvent



Filling material:
PS-DR1 with solvent



- Complete filling in one step
- Alignment of chromophores (poling) is difficult because of simultaneously occurring crosslinking
- Film thickness is about 500 nm
- Multiple filling steps are required
- Poling is straight forward



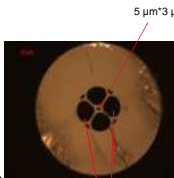
Both the materials can be combined to completely fill the holes and at the same time achieve high EO activity

3. Poling

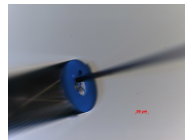
- Electrodes are required for poling
- Alignment of chromophores by applying an electric field

1. Poling electrodes made by inserting a metal wire

A suspended core PCF



The central hole selectively filled with Epoxy-DR1

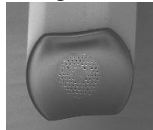
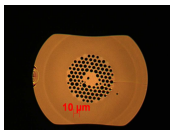


20 μm Tungsten wire inserted into 30 μm hole to a length of 5 cm

-30 μm for electrodes

2. Poling electrode sputtered on D shaped fibers (Further lithography required for structuring)

PCF with double D, Surface completely covered with 100 nm of sputtered gold



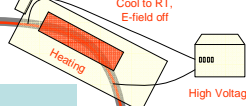
3. Poling electrode made by filling liquid metal



PCF with gallium filled holes

PCF with empty holes

Vacuum pump 10⁻⁵ mbar
Heating the fiber close to the Tg of the polymer, E field ~100 V/ μm for 30 mins, Cool to RT, E-field off



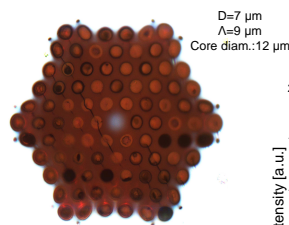
Conclusions

- PCFs can be filled with EO polymers to a length of about 10 cm
- Solvent free monomer (Epoxy-DR1) is needed to completely fill the holes with EO material
- Possible electrode configurations using metal wire insertion and filling with liquid metal have been demonstrated
- The presented concepts enable further poling of these fibers filled with EO materials

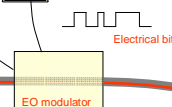
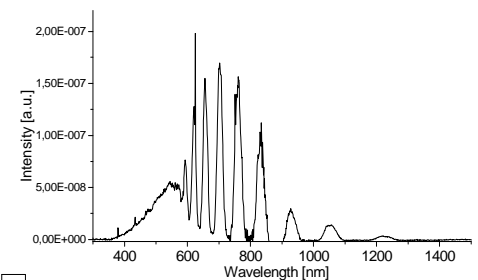
4. Transmission spectrum of solid core PCF filled with EO polymer

- Solid core PCF filled with Epoxy-DR1
- Transmission measured before poling
- Dips in the transmission correspond to the cutoff of the rod modes

Microscope picture of a solid core PCF with the holes filled with Epoxy-DR1



Transmission of 8 mm length of the filled fiber



Optical bits

010 010 010 010 010 000 000 000 100 111 011 011

Acknowledgement

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