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CASE STUDY

UV16: Utilized in Bonding Applications for Microring Resonators, Optical Waveguides and Confocal Microscopes

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Used in a wide range of applications, UV16 exhibits many properties that are advantaged for both performance and handling. Its viscosity is between 250-500 cps, greatly facilitating application where thin layers are desired. Its low shrinkage (1-2%) ensures the application surface area is primarily maintained after curing. UV16 exhibits a low refractive index of 1.511, which minimizes performance loss for electronic resonance reduction products. Since this is a one component system, there is no mixing involved, and it cures rapidly upon exposure to UV light at 365 nm. The polymer exhibits very high tensile strength/modulus and electrical insulation properties, mitigating weakening from exposure to extreme heat. Finally, UV16 is a cationic type cure system, which cures tack free and is not oxygen inhibited.

The properties of UV16 make it an excellent choice for many applications, including resonance extinction and biomedical products. The following are summaries of three use cases of UV16. Below is a table describing the applications and uses of UV16 summarized in this study.

Table 1: Commercial and Research Uses of UV16

Industry	Application	UV16 Uses	Critical Properties
Optical modulators	Microring resonators	Provide high-integrity bond between substrate and solution	Low viscosity for decreased bond thickness
Optical modulators	Polarity-independent optical waveguides	Provide high-integrity bond between substrate and solution	Low viscosity for decreased bond thickness
Instantaneous tissue scanning	Miniature endoscopic confocal microscope	Enable fluorescent dye imaging and bond DOE to lens with create zero-gap seal	Low refractive index for dye imaging and low viscosity for minimal wicking and shrinkage

Microring resonators fabricated by electron beam bleaching of chromophore doped polymers

Application

Optical modulators containing high Q-factor microring resonators are gaining popularity due to their robust functionality and compact size. The resonators enable exponential growth of electro-optical (EO) coefficients on the order of Moore's Law. Microring resonators may also allow lossless power conversion due to their ultrafast response time.

Researchers at the University of Washington in Seattle used electron beam bleaching to fabricate microring resonators. They used the chromophore YL124, historically used for optical rectification and EO modulation, and doped it at a 20% loading density into the PMMA host polymer. The PMMA host had a molecular weight of 950,000, making it an attractive candidate for electron beam resist. The solid mixture was then dissolved in liquid chlorobenzene, and the resultant solution was then spin coated onto a silicon substrate. UV16 was precoated and cured on the substrate's surface, acting as a cladding material to ensure sufficient adhesion of the doped polymer to the substrate. Electron beam bleaching formed the desired microring structure. A vacuum oven heated the polymer film at 65°C.

Key Parameters and Requirements

The objective of the microring is to dissipate resonance; so, the target metric is the maximum-achievable resonance extinction ratio, which defines optimal resonator characteristics for the application. The researchers used two applications, transverse electric (TE) and transverse magnetic (TM) polarization, to determine the resonator specifications. The highest resonance mode present in both spectra defined the target extinction ratio.

The UV16 polymer enables electron beam writing of the microring by maintaining a robust and high-integrity bond between the substrate and solution. Without it, the high resonance extinction ratios may not be achieved.

Results

Electron beam irradiation decomposes chromophore molecules to reduce the refractive index of the polymer. The electron beam bleaching process enables the usage of microring resonators, which require a polymer adhesive that avoids organic solvents that can attack the chromophore. UV16 provided the thin adhesive layer and desired bond characteristics that enable the fabrication of these resonators.

Polarization selective electro-optic polymer waveguide devices by direct electron beam writing

Application

A study from the University of Washington in Seattle aimed to mitigate undesired polarization for TE and TM modes. Polarization can cause signal fading and performance degradation in fiber optic communications devices. To reduce this effect, the researchers wanted to make the optical components polarization independent. To achieve that, they targeted two of the common characteristics that lead to polarization: geometric asymmetry and stress-induced birefringence. Design and fine adjustment of the waveguide refractive index profile can enable a circular optical mode shape that eliminated the geometrical birefringence.

While it is impossible to eliminate variations in polarity in optical waveguides, the study notes that splitting the TE and TM modes and removing one orthogonal mode in the waveguides are two additional ways to create polarity independence in optical devices. The waveguide itself can be designed to be polarization-selective, which can actively target which polarity mode to target.

EO polymers with large EO coefficients and low dielectric constants are preferable for high-speed EO modulators. The investigators fabricated a polarization-selective EO polymer waveguide and microring resonator capable of creating polarization-independent optical components.

Key Parameters and Requirements

The experiments employed three waveguide EO material systems. Each consisted of a layer of EO-curable polymer that was spun-coated onto a silicon substrate and UV cured. The composite material was then baked in a vacuum oven between 65-85°C to remove undesired crosslinked monomers that would weaken the adhesion bond. Two samples used UV16, with the other employing OG125.

The primary performance metric used to assess the systems is the extinction ratio. The combination of host polymers and EO chromophores produces various optimal electron beam doses due to differing sensitivities to the electron beam and poling-induced birefringences. As a result, the highest extinction ratio for a given material system has a respective beam dosage. In addition to peak extinction ratio, refractive index and poling temperature can help to confirm the better-performing material system.

Results

The peak TE/TM extinction ratio was 21 dB at a beam dose between 90-100 $\mu C/cm^2$ for the first material system (sample A), which used OG125 EO polymer. Peak ratios for the second and third material systems (samples B and C, both of which employed UV16 polymer), were 18 dB at a beam dose of 1000 $\mu C/cm^2$ and 21 dB at a beam dose of 200 $\mu C/cm^2$, respectively. The study confirmed that UV16 could be used to produce microrings that enable the highest attainable levels of resonance extinction ratios.

Objective lens for a miniature endoscopic confocal microscope

Application

A 2005 master's thesis from Montana State University investigated the design and performance validation of a miniature endoscopic confocal microscope. This technology could lead to dramatic advancements in biomedicine by providing substantially improved inspection, analysis, and diagnosis through in-situ imaging. Before its development, medical professionals would have to take samples from the native source and image on a microscope. Time and capital are expended to transfer the tissue and analysis at another location. Confocal endo-microscopy (CEM) is the in situ scanning of tissue with a confocal scanning microscope with illumination delivered through an optical fiber.

Key Parameters and Requirements

The principal objective of the thesis was to design a miniature confocal microprobe for instantaneous tissue scanning. The researcher limited target dimensions of the probe to maxima of 2.0 mm diameter and 10.0 mm length. System NA was 0.33, with 4x magnification. Optimally, the scan would occur at two wavelengths, 488 and 515 nm to implement fluorescent dye imaging. The diffractive optical element (DOE) needed to be attached to lens using an optical adhesive, UV16. The study cited beneficial properties of UV16, including refractive index (1.517), ultra-low viscosity (120-150 cps) and less than 2% shrinkage during curing. The essential characteristic was the viscosity, which enabled an ultra-thin adhesive layer between the lens and DOE. UV16 epoxy is very resistant to both solvents, acetone and isopropanol. The adhered assembly could be submerged in acetone in a cleaning step to remove excess process residue.

Results

The research successfully achieved its desired results, with lens dimensions of 4.0 mm length and 2.0 mm diameter (1.6 mm diameter without packaging). UV16 epoxy proved to be robust and the proper adhesive choice.

Another application of UV16 was to assemble the refractive lenses and the DOE. Assembly utilized high accuracy stages to precisely align the DOE with the lens. The research team again used UV16 for the adhesive. After completing the lens assembly, the end of the tube was sealed with UV16 to create surface contact with the tube without a gap.

The author listed properties of UV16 that lead to improvements to the application. The lenses need to be perfectly aligned without getting scratched during assembly. Introducing transparent film between the lenses before coating with epoxy would avoid undesired wicking into the lenses due to the low viscosity of UV16, while simultaneously preventing scratching during insertion of the lenses into the housing. Coating the entire assembly with UV16 is the best way to ensure sufficient adhesion without scratching while minimizing the thickness of the epoxy layer through its very low viscosity.

References

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