

PHOTODEFINABLE ELECTRO-OPTIC POLYMERS FOR HIGH SPEED MODULATORS

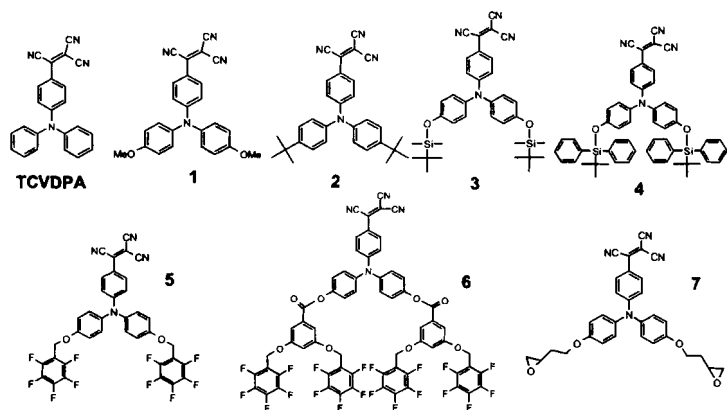
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We present a series of polymeric electro-optic (EO) materials based on the tricyanovinylidenediphenylaminobenzene (TCVDPA) chromophore which exhibits an exceptionally high photostability combined with a high EO activity. The synthetic work that has been done includes three main parts: the bulky TCVDPA derived chromophores to be incorporated into a polymer forming a guest-host system; the epoxy-functionalized TCVDPA to be covalently inserted into a polymer matrix with a degree of crosslinking; TCVDPA-containing side-chain polycarbonates to be directly used as the EO active layer.



Scheme 1: TCVDPA derived chromophores

For the TCVDPA chromophore, an r_{33} coefficient of 6 pm/V was measured at a concentration of 25 wt% in SU8. Comparatively, TCVDPA was mixed into a polysulfone (PSF) at different concentrations, and the corresponding r_{33} values were measured. As can be seen from

Figure 1, a deviation from the linear relation was observed above 15 wt% of TCVDPA, suggesting the occurrence of chromophore clustering. For the bulky TCVDPA derived chromophores, most materials have a reasonable thermal stability, and all of them have a low absorption window in the UV-vis spectra, which enables the photodefinition for waveguide fabrication. The EO properties of these derivatives are given and the best result was obtained with the di-*t*But derivative **2**, which showed a nearly doubling effect of r_{33} (14 pm/V to 25 pm/V), while increasing the concentration from 25 wt% to 37.5 wt%.

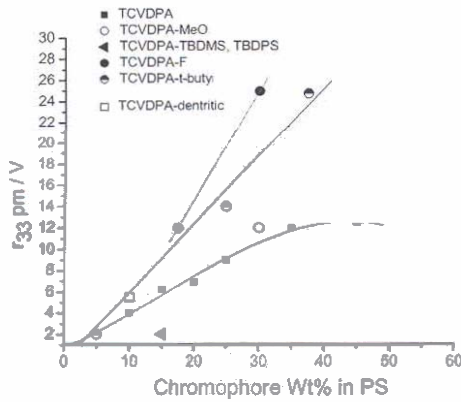


Figure 1: Measured r_{33} coefficients for different TCVDPA modifications in SU8 or PSF at 830nm.

make them suitable for EO applications.

A microring resonator design was made based on the PC-TCVDPA system. Waveguides were fabricated by photodefinition of inverted ridges in VSC, a negative epoxy based photoresist with low refractive index. A bottom VSC layer was spin coated on a silicon wafer and exposed to UV light via a bright field mask followed by development. The inverted ridges were then filled with PC-TCVDPA by spin coating. A top cladding of an UV curable epoxy with low refractive index (UVR) was spin coated and cured by UV exposure and baking.

Reactive ion etching (RIE) was selected to fabricate devices as an alternative to photodefinition. PMMA-DR1 was chosen as the initial material with the idea of replacing PMMA-DR1 with PC-TCVDPA in the final devices. The inverted structures were defined in VSC by RIE and then filled with PMMA-DR1. A microscope picture of microring resonator made by RIE is shown in Figure 3.

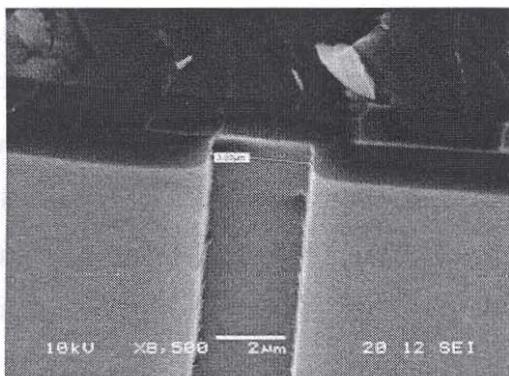


Figure 2: Photodefined inverted ridge in VSC

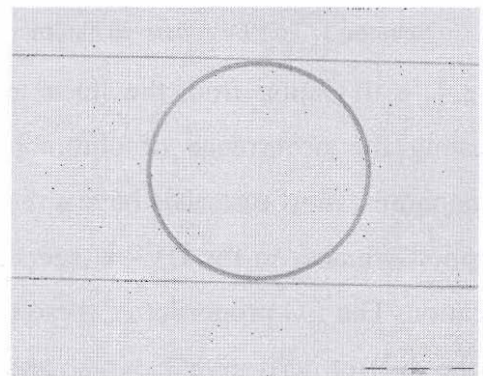


Figure 3: PMMA-DR1 microring made by RIE

Optimization of the NLO response can be achieved in several ways as increasing the chromophore number of density (N), although one drawback of this procedure is the fact that the chromophore acts as a plasticizer decreasing the T_g of the polymer. To overcome this problem TCVDPA has been incorporated into the polymer backbone leading to different modifications of the TCVDPA side chain polycarbonates (PC). The resulting polymers have been tested showing a greatly higher chromophore loading density (50%) than that of the host-guest systems and a reasonably high T_g (205-215 °C) that