UV Curable Low Refractive Index Clad Coatings
for
High Power Fiber Laser Applications

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INTRODUCTION

One of the key interests in fiber lasers industries for industrial, military, scientific, and medical applications is increasing power output. CW fiber-lasers are capable of delivering a beam having a power in excess of 1 kilowatt (kW) with high optical efficiency between 60% ~ 90%. Low refractive index polymer coatings play a key role in guiding the pump light used to power the gain glass core and clad media in double-clad (DC) fibers. The main failure modes of these low refractive polymer coatings in kW power fiber lasers are delamination and colorization that scatter pump light. The mechanical and thermal resilience of UV curable fluoroacrylate coatings are the key limitations in the development of kW power fiber lasers. This paper addresses the thermal resilience of a new UV curable fluoro-siloxane coating developed by Luvantix ADM including a comparison with PC373 series which are widely used in the DC fiber laser industry.

METHODS

<u>UV Curable Urethane Acrylate</u>

(Per)fluoropolyether (PFPE) diol and isophorone di-isocyanate (IDPI) were reacted with hydroxyethyl acrylate (HEA) to form UV curable fluoro-urethane oligomers which have low refractive index. The general chemical structure is described in figure 2 below.

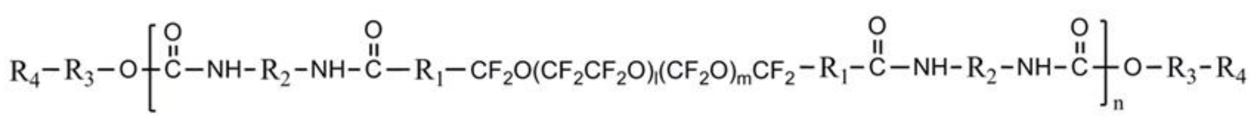
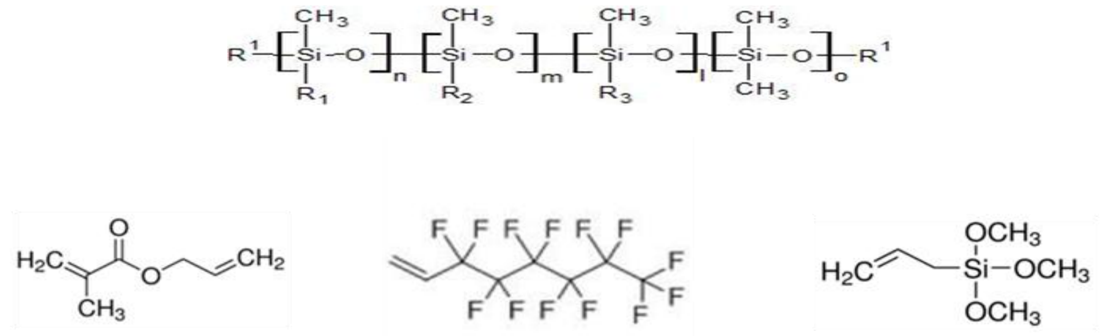


Figure 2. General chemical structure of fluorinated oligomer where R4 is acrylate moiety for UV curable function.

<u>UV Curable Fluoro-Siloxane Oligomers</u>

UV curable fluoro-siloxane oligomers which have a general chemical structure described in Figure 4.



R1 = Allyl methacrylate R2 = (Perfluorohexyl)ethylene R3 = Allyltrimethoxysilane

Figure 4. General chemical structure of UV curable fluorinated siloxane copolymer.

UV curable polymer cladding formulation

UV curable polymer cladding formulations using above oligomers are listed in Table 3. PC 375LAP from Luvantix ADM Co., Ltd. was used as the standard and compared with these new formulations.

	PC375LAP	PC-Ure A	PC-Ure B	PC-Silox A	PC-Silox B	PC-Silox C
Ure-Oligomer A		87.0%				
Ure-Oligomer B			87.0%			
Silox-Oligomer A				87.0%		
Silox-Oligomer B	Standard				87.0%	
Silox-Oligomer C						97.0%
Monomer		10.0%	10.0%	10.0%	10.0%	0.0%
Photo-initiator		3.0%	3.0%	3.0%	3.0%	3.0%
Total Wt%		100.0%	100.0%	100.0%	100.0%	100.0%

Table 3. UV curable polymer cladding formulation

Thermal and optical analysis

Thermogravimetric analysis (TGA) was used to measure changes in weight of cured polymer cladding samples as a function of increasing temperature up to 600°C. Yellowness of cured samples were measured by color index instrument based on ASTM E313

RESULTS

Thermogravimetric analysis (TGA) of PC resins

Compared to PC375LAP, TGA of PC-Silox A, B and C show quite higher Tg by as much as 100°C. PC-Silox series do not contain urethane linkage but it's main linkage of oligomers is siloxane linkage Si-O-Si. The lower silicon electronegativity yields a highly polarized thereby highly ionic Si-O bond, resulting in

a large bond energy, 452kJ/mole which is much higher than a C-C, C-N, C-O bond in urethane. The thermal stability of the siloxane polymer stems from this high bond energy.