L.5: Development of 200 mm diameter AR coated optics with high LIDT for high energy laser

Nd:glass (phosphate) optimally fulfils the requirements for being considered as material for developing high energy high peak power lasers mainly for the generation of intense x-rays, study of materials at extreme temperatures, pressures etc. RRCAT, Indore has embarked on the challenging programme of building such a laser indigenously.

Nd:glass disc amplifier and vacuum spatial filters of the high energy laser chain require large (dia, 200 mm) anti-reflection (AR) coated windows with high transmission and high laser induced damage threshold in nano-second regime. As such large windows with high transmission and high LIDT are not readily available from the OEMs, it is imperative to develop these windows indigenously.

Indigenous development of these crucial optical components has been carried out at High Energy Laser and Optics Division, RRCAT. This includes substrate fabrication, super-smooth optical polishing, coating design, deposition of AR coating and characterization.

To achieve this, substrates should have an ultra-low roughness, surface with minimum cosmetic defects e.g., scratches, digs and pits. Ultra-low roughness substrates significantly reduce scattering and absorption of radiation, thereby enhancing transmission and the LIDT of the optical components.

Super smooth optical polishing of fused silica (FS) substrates was carried out using bowl-feed Chemical Mechanical Polishing technique. The process is extremely slow. Surface figure $\leqslant \lambda/10$ @ 589 nm, roughness better than 0.3 nm and scratch/dig ~ 20/10 were achieved as the process was optimized for 200 mm optics as shown in Fig. L.5.1.

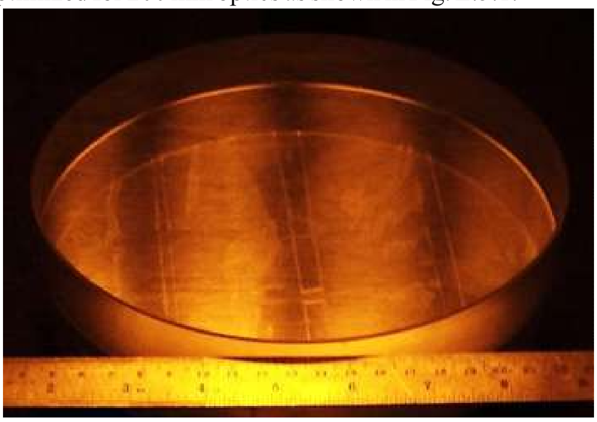

Fig. L.5.1: 200 mm super-polished FS substrate after super smooth polishing, flatness better than λ/10, scratch-dig ~ 20/10 and r.m.s. roughness 2.2Å.

Subsequently optical thin-film coating was deposited on both the substrates. A 3-layer anti-reflection coating was designed and optimized in such a way that electric field at the first SiO_2/HfO_2 interface is reduced while maintaining high transmission. Deposition of alternate SiO_2 and HfO_2 layers was carried out by dual ion beam sputtering technique. Before making the final coating on 200 mm optics trial coating runs were made for validation of the design optimization. 3 layers have been deposited in a single run of 3 hours. Same process was repeated for coating of the reverse side. Process parameters were meticulously monitored and controlled. Coated optics (Fig.L.5.2) were characterized by transmission and laser damage threshold measurements.

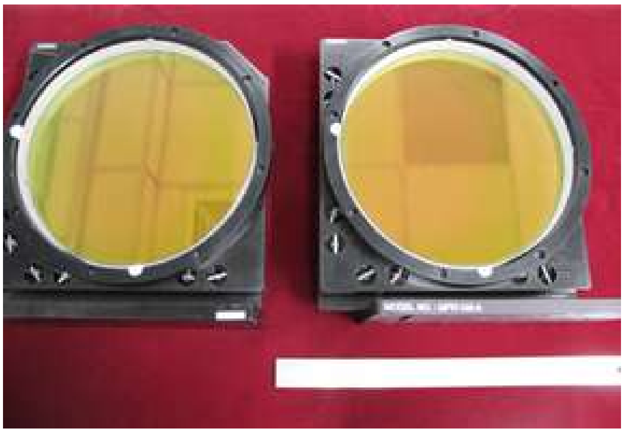

Fig. L.5.2: High transmission, high LIDT AR coated optics with T= 99.4%, LIDT = 15.8 J/cm² @ 5 nsec.

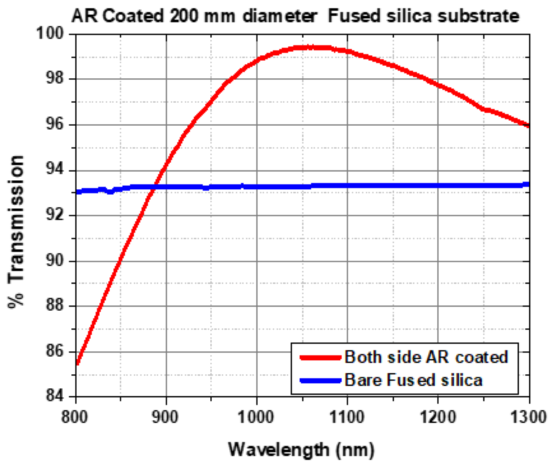

Fig. L.5.3: Transmission spectra of 200 mm dia. AR coated optics and bare substrate.

99.5 % transmission @ 1053nm and an uniformity of 0.1% are measured. Transmission 99.2 % over a wavelength band of 80 nm is obtained (Fig. L.5.3). Laser induced damage test was performed on AR coated samples with the standard 10-ON-1 method as per ISO Standard procedure (ISO-11254-1). Laser damage threshold of 15.8 J/cm^2 @ 5 ns (10-ON-1) and 20.6 J/cm^2 @ 5 ns (1-ON-1) are measured with in-house developed LIDT test set up.

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