Ultra-high quality factor $\text{Al}_2\text{O}_3$ coated silica microspheres

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Spherical silica microcavities are among the highest optical quality factor microresonators ever fabricated [1]. Such characteristic have been explored to demonstrate a plethora of low-power nonlinear optical effects in these devices, such as Raman lasing [2] and Kerr frequency combs [3], as well as single-molecule resolution optical sensors [4]. Such high quality factors, up to $10^9$ result from the thermal fusion process often employed in their fabrication, which ensures atomic-level surfaces roughness. Some of these interesting nonlinear effects however, such as Kerr frequency combs, requires strict momentum conservation (phase-matching) to be full filled. The phase-matching condition requires control of the group velocity dispersion (GVD) but, due to their single geometric degree of freedom - the diameter - microspheres do not allow precise dispersion engineering. Recently, several theoretical papers have investigated the microsphere GVD dependence on the distinct coating materials [5].

Here we experimentally demonstrate that $\sim 250$ $\mu$m optical microspheres, fabricated from a commercial fiber-fusion splicer and coated with alumina ($\text{Al}_2\text{O}_3$), can sustain optical quality factors up to $10^7$. Atomic force microscopy (AFM) confirms sub - 5 nm RMS roughness for the atomic layer deposition (ALD) coating with thickness ranging from 50 nm to 130 nm. Our experimental data is complemented with numerical simulations showing that the $\text{Al}_2\text{O}_3$ layer thickness, ranging from 50 nm to 150 nm, allows for precise tuning of the zero GVD wavelength.

We envision that such a high-$Q$ resonator coated with alumina could be readily used to improve the spectral range of Kerr frequency combs through dispersion engineering.

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References:


