Supplemental Materials: Remarkably high-Q resonant nanostructures based on atomically thin two-dimensional materials

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In our paper, we have ignored the losses by material absorption and fabrication errors etc. So, in theory, the thinner the grating, the smaller the coupling and scattering losses, therefore the higher the quality factor. However, losses are inevitable for practical situations. When the loss exists, it will overplay the scattering losses and play a dominating role when the grating thickness reduces to a certain value, leading to a saturation of the Q factor. Moreover, as the coupling continues to be smaller and smaller, the resonance will damp due to the absorption losses (the coupling coefficient becomes smaller than the absorption coefficiency). Finally, the resonance will disappear when the thickness is too small in the presence of loss.

Here we show calculations with three kinds of conditions: (1) the whole structure is lossless, (2) silicon (waveguide layer) is lossy with a small image part of refractive index ($n = 3.4 + 10^{-6}i$) and (3) silicon (waveguide layer) is lossy with a small image part of refractive index ($n = 3.4 + 10^{-5}i$) [the loss can be attributed to material absorption or fabrication errors etc]. And we continuously reduce the thickness of hBN grating from 0.42 nm to 0.042 nm (please note that 0.42 nm is the thickness of monolayer hBN. A smaller thickness is meaningless for practical realization, but the numerical simulations can help us understand the role of losses on the resonances when the grating becomes very thin). To curtail the simulation time, we use another simulation software named Rsoft when the thickness of grating approaches zero. The module DiffractMOD in Rsoft is based on the Rigorous Coupled Wave Analysis (RCWA) method. And the results simulated by Rsoft agree well with previous simulation in the article.

The calculated optical spectra are depicted in Fig. S1. For the lossless situation, the reflection peak can still reach 100% even though the thickness is reduced to one-tenth of monolayer hBN with an Q-factor of 3×10^8. When we introduce a little loss to the silicon, reduction of thickness in a reasonable range can improve the quality factor. Nevertheless, if we reduce the thickness of grating continuously, the quality factor will tend to saturation (See Fig. S2) and the amplitude of resonance will decrease quickly to zero (See Fig. S1).

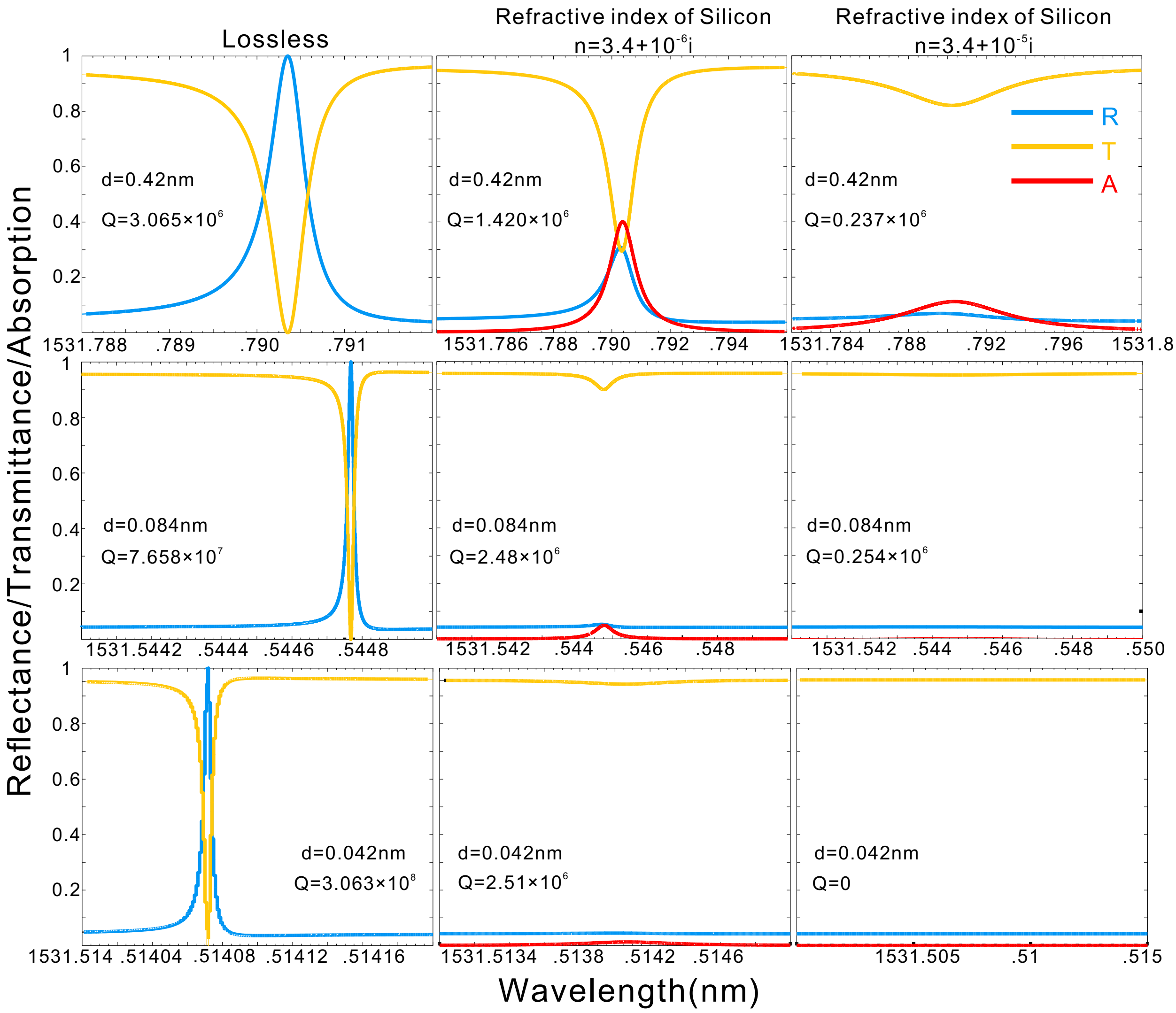

FIG. S1: Diffraction efficiency of different thickness of hBN grating layer with different loss conditions: (Left column): lossless; (Middle column): image part of refractive index of $Si = 10^{-6}$; (Right column): image part of refractive index of $Si = 10^{-5}$.

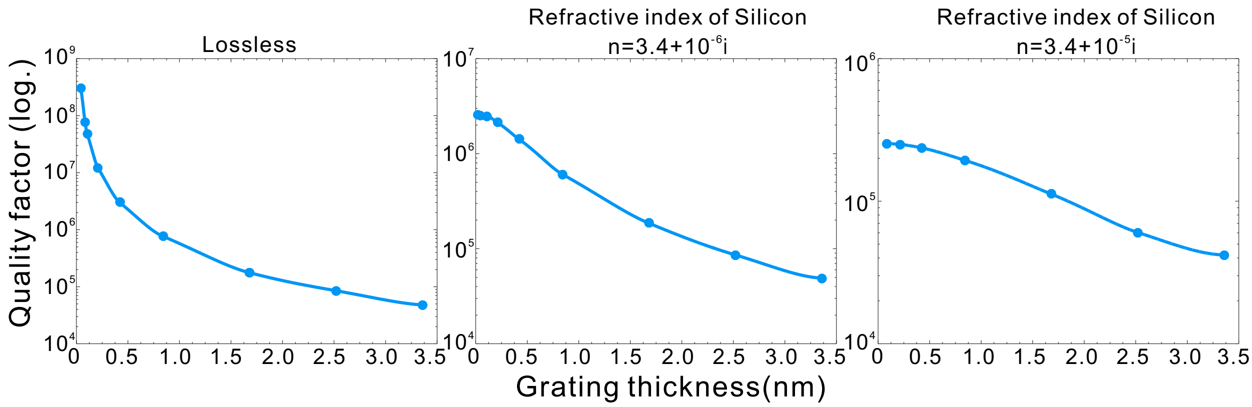

FIG. S2: Quality factor in logarithm for different thickness of grating when the loss conditions are: (left column): lossless; (middle column): image part of refractive index of $Si = 10^{-6}$; (right column) image part of refractive index of $Si = 10^{-5}$.