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Mode-in-the-Box via Mode-on-the-Box

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Abstract. Cavity resonator integrated grating filters are very promising reflection filters that exhibits very narrow spectral width (smaller than $\lambda/1000$) even when they are illuminated with a focused beam (around 10λ). They are composed of a coupling grating surrounded by two Bragg reflectors. Their numerical modelling is possible but requires long calculation times, thus design rules are useful. In this work we are interested in controlling the spectral width of CRIGF. Narrow band free space spectral filters are required in some applications such as telecommunications, spectroscopy, detection and sensors. Guided mode resonance filters (GMRF) consist inof a thin stack of dielectric layers on top of which with a sub-wavelength grating is etched on top. The excitation of an eigenmode through a given diffraction order of the grating (called further on coupling grating) generates a resonance peak in the reflectivity or transmittivity spectrum that can have a very narrow spectral bandwidth. The Q factor (wavelength over bandwidth ratio) can easily reach 10000 experimentally. Moreover, the reflectivity at resonance reaches 100% under symmetry conditions that can be easily fulfilled, leading to a good filtering efficiency in reflection provided the whole structure is designed as an anti-reflection coating outside the resonance. Unfortunately, GMRF have considerably weak angular tolerances that hinder their application. Illuminating a GMRF with a non-collimated beam crushes down the resonance peak. The angular tolerance can be improved by increasing the coupling between the modes by using a "doubly periodic" basic element, or equivalently by inserting into the structure a distributed Bragg reflector (DBR) in addition to the coupling grating. The DBR and the coupling grating can be placed one above the others, thus constituting an infinite grating, or with the coupling grating of finite length inserted between the two DBR. This second structure is characterized by much larger angular tolerances, preserving an almost total reflection over 5 degrees of angle of incidence, still keeping its narrowband spectral width of less than 2 nm.