Dual prism/Bragg reflector coupled evanescent states for filter/terahertz applications

S Brand, Department of Physics, Durham University.

Interface states are known to exist at the surface of an appropriately structured Bragg reflector. If such reflectors are present on the surfaces of two prisms separated by a narrow gap the evanescently coupled interface states can interact to produce a pair of very narrow transmission lines the separation of which can be adjusted by varying the size of the gap between the two prisms. Thus, although only a single cavity is involved, the spectral properties of the system are similar to those of a dual cavity photonic microstructure. The structure has potential applications as a tunable dual frequency filter, a single flat-top notch filter, as a sensor, and if used as a means of laser mode selection, as a component of a terahertz frequency source as well as a means of laser mode selection/control in an otherwise conventional laser system.

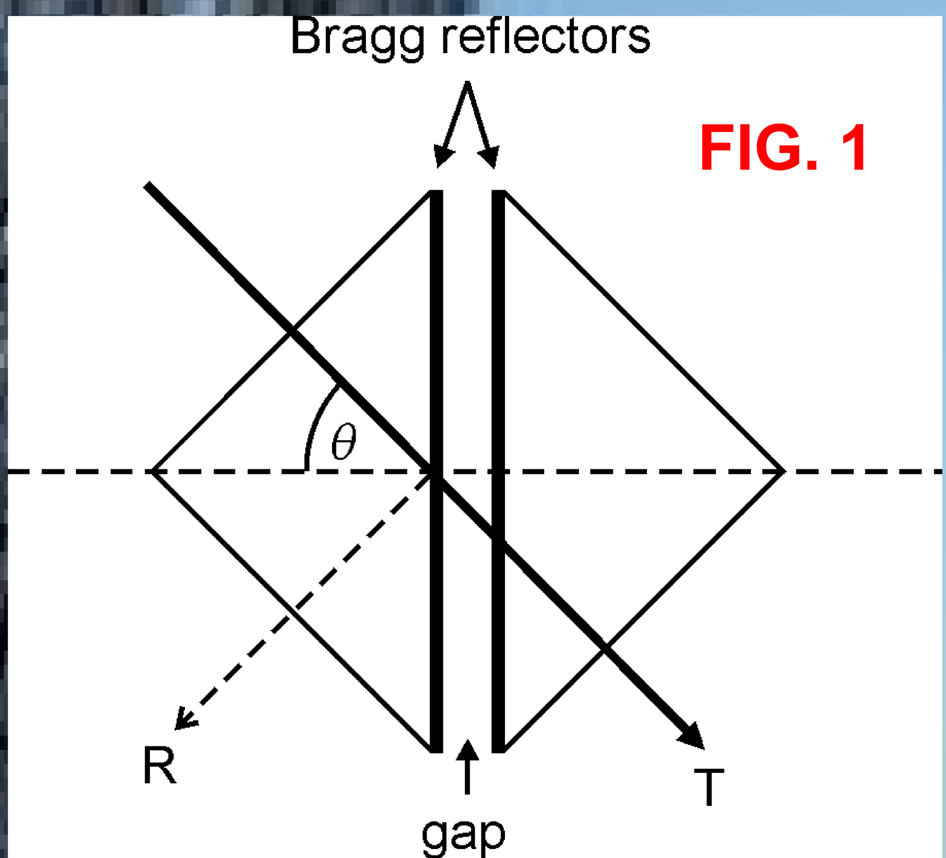

FIG. 1

FIG. 1 shows a structure consisting of two back-to-back prisms with Bragg reflectors (BRs) on their surfaces separated by an air gap. In the present calculations the BRs consist of 17 layer pairs of TiO_2/SiO_2 (204/328 nm) taken to have refractive indices of 2.37/1.47 respectively followed by a final TiO_2 layer (265 nm). The prisms are taken to have a refractive index of 1.47. As the angle θ = 45° this is above the critical angle of 42.9° for the prism/air system and hence total internal reflection (TIR) occurs at the final interface. However, this structure supports a photonic interface state with an energy of 0.8 eV (the corresponding free space wavelength is 1549 nm). The interface state is a result of TIR on one side of the interface and the existence of a photonic band gap (PBG) at the corresponding energy in the BR on the other. Hence, when a small air gap of a few microns is present between the two prisms the coupling between the evanescently coupled interface states leads to a pair of transmission lines in the associated spectrum as shown below in **FIG. 2**. The reflected light follows path R.

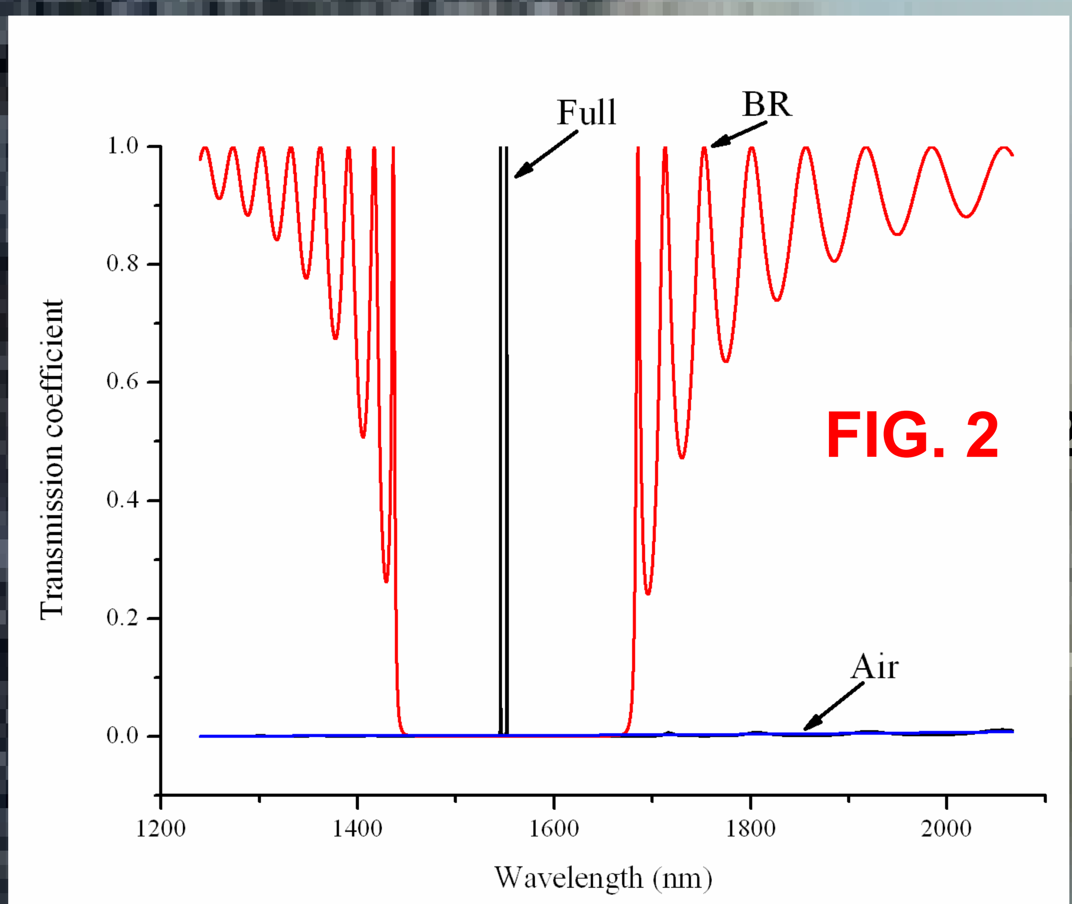

FIG. 2

FIG. 2 shows the transmission associated with a standard PBG structure with no air gap (BR), for a dual prism/BR structure with a 3.5 micron air gap (Full) and for a system consisting of two prisms with a 3.5 micron air gap and no BRs (Air), the latter exhibiting almost no transmission over the wavelength range considered. For the purposes of the calculations the outer prism surfaces are extended to infinity. A more detailed plot of the transmission as a function of air gap width is shown in **FIG. 3**.

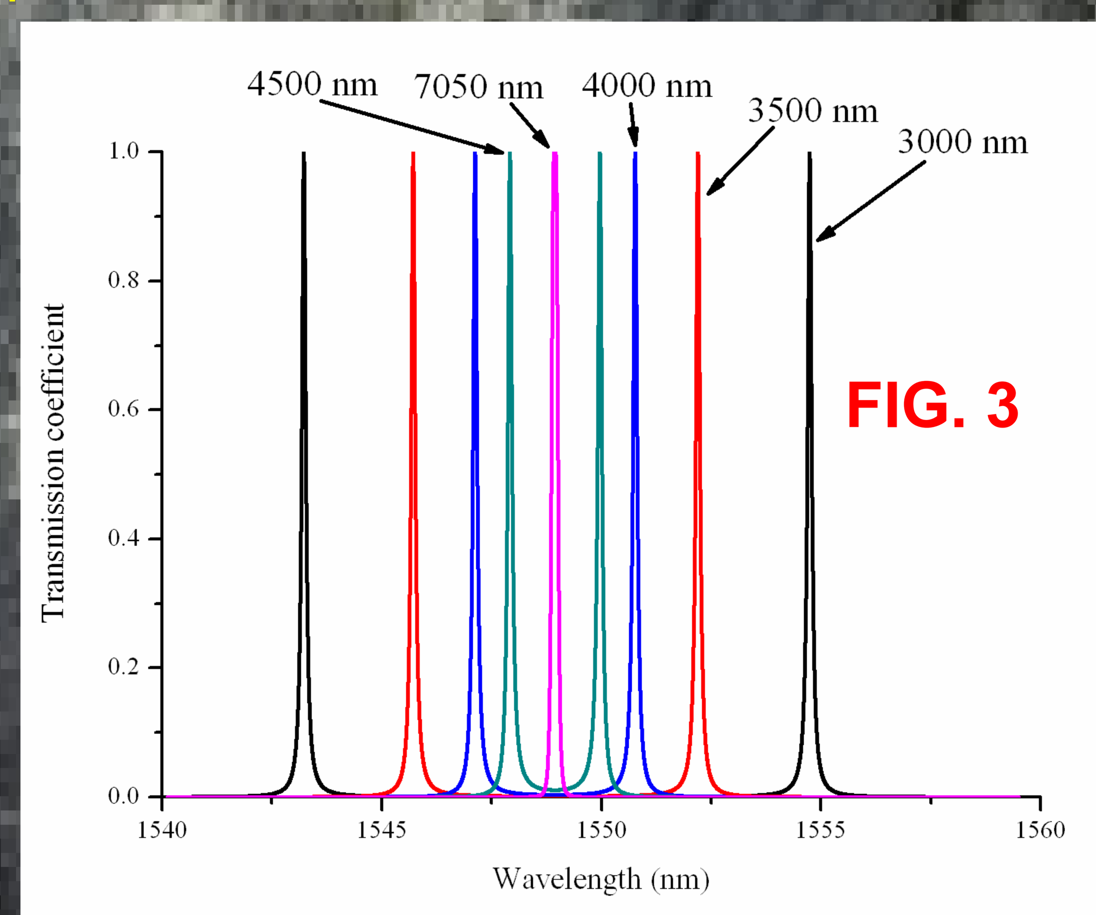

FIG. 3

The structure acts in effect as a narrow line dual frequency filter although, when the air gap is about 7 microns, in the weak interaction limit, a single flat-top transmission line is seen, a property normally associated with an appropriately designed dual microcavity structure. Note that more generally the separation of the two transmission lines is in the terahertz regime: with an air gap of 3.5 microns the separation of the transmission lines is about 0.8 THz. Plots of the time-averaged component of H^2 relative to that of the incoming wave are shown in **FIG 4** and **FIG 5**, demonstrating that there is a significantly enhanced field within the air gap. The dotted lines indicate the location of the air gap.

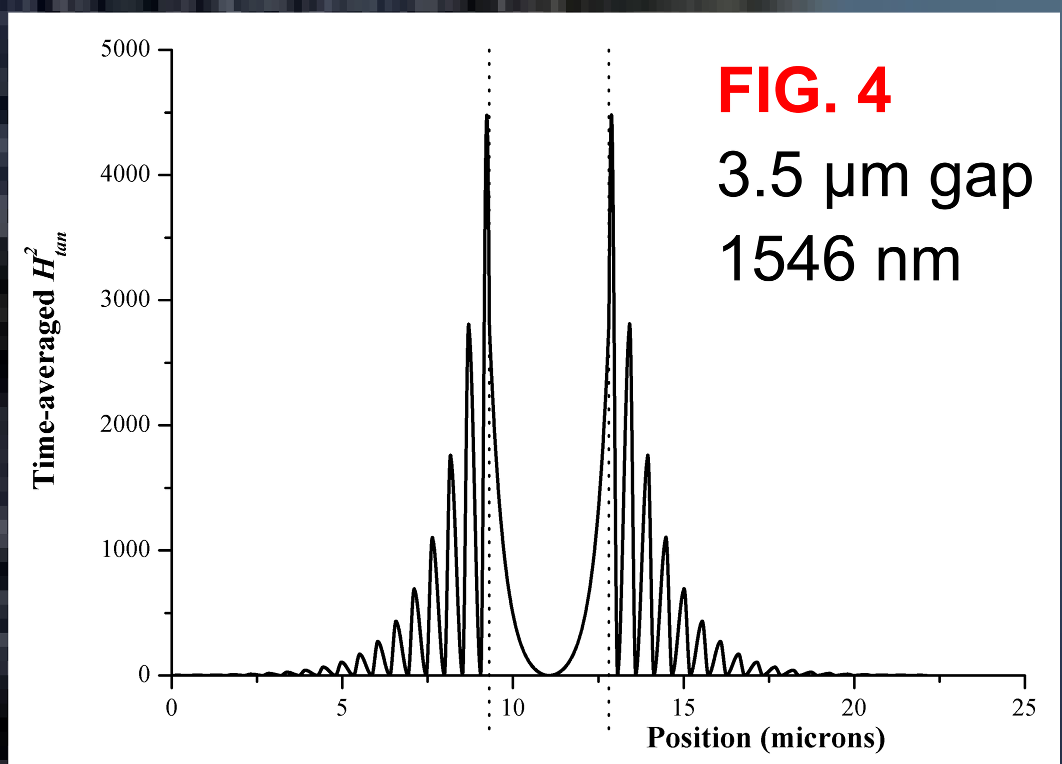

FIG. 4
3.5 μm gap
1546 nm

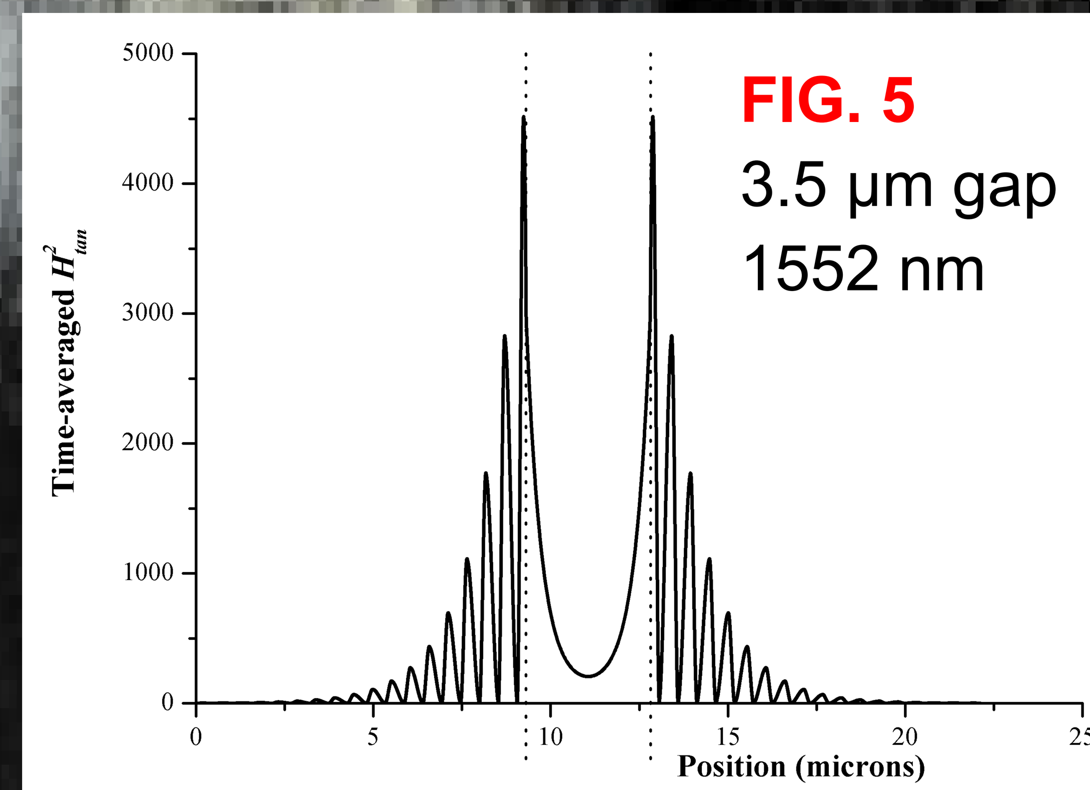

FIG. 5
3.5 μm gap
1552 nm

Note that the position and sharpness of the transmission features can be adjusted by altering the widths and number of layers in the BR, angle of incidence and, in particular, the thickness of the final layer in the multilayer structure and the material composition. If this type of structure were used to control laser emission the output could, in principle, be directed at a suitable external photomixer to generate THz radiation. In one scenario the prisms themselves could constitute the laser medium with appropriate non-linear material within the gap in order to take advantage of the enhanced field within that region. As the transmission is sensitive to the refractive index of the material within the gap the structure could be employed as the basis of an imaging system.

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All calculations employ a transfer matrix approach and are for TM polarization in which the *H*-field is parallel to the interfaces.

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