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| **Exam Microphotonics**  Prof. R. Baets & Prof. D. Van Thourhout  24/1/2020 Morning  Start a new sheet of paper for each question!! Write your name on all pages.  In parallel with the written open-book exam there will be an oral closed book discussion with both lecturers (about other questions). |

**Question 1**

A plane wave with a wavelength of 1 micrometer is incident from glass (n=1.5) on a coating with refractive index n2 and thickness d, followed by air.

1. Choose d and n2 such that the reflected power is zero for normal incidence. If there are multiple solutions choose the solution with the thinnest coating.
2. With those values for d and n2 calculate the reflectivity of the structure (both in amplitude and in phase) when changing the angle of incidence. More specifically calculate the reflection for an angle of incidence of 15, 30, 45 and 60 degrees. Do this for s-polarization. Explain the observed behavior.

n1=1.5

n3=1

n2

d

**Question 2**

A non-transparant plate with two very small holes (much smaller than the wavelength of light) is positioned at a distance 2f away from a lens (with focal length f). In the image plane an image is formed of the two small holes. The distance between the two holes in the plate is 5 micrometers. They are close to the lens axis. The diameter of the lens is f/10. The lens is free of aberrations.

Describe how the light intensity in the image plane will look like for the following three situations:

1. The plate is illuminated by incoherent light with a spectrum centered around a wavelength of 1 micrometer
2. The plate is illuminated by a coherent laser beam parallel with the lens axis. The laser wavelength is 1 micrometer
3. As in b. except that the laser beam travels at an angle relative to the lens axis such that the optical field emerging from the two holes has a phase difference of 180 degrees

In your answer you can either make use of qualitative drawings or of more exact analytical expressions. Both are acceptable. But do describe in words what the characteristic differences are between the three images.

**Question 3 and 4: see back side of this page**

**Question 3**



Consider the integrated interferometer as sketched above. It consists of:

* A perfectly symmetric Y-junction
* Two waveguide arms. In the upper arm we can introduce a phase shift 
* A directional coupler with length L.

For each of the cases described below, calculate and sketch how the power transmission T1=P1/Pin and T2=P2/Pin to the output waveguides varies, if we change the length of the directional coupler from 0 to 2Lc. Lc is the coupling length of the directional coupler defined in section 5.3.2 of the course.

1. No phase change in upper arm (=0), symmetric directional coupler (=0, ).
2. No phase change in upper arm (=0), asymmetric directional coupler (≠0, ).
3. Phase change in upper arm =/2, asymmetric directional coupler (≠0, ).

For the definition of the symbols see section 5.3.2 in the course.

**Question 4**

Consider a grating with size (width) 68mm, containing 1200 lines/mm and operated in the first order mode. The wavelength is 500nm.

1. What is the theoretical resolving power of this grating ?
2. This grating is used in a Czerny-Turner spectrometer with exit slit s=16m and focal length f=500mm. What is then the practical/actual resolving power and resolution of this system ? Compare with (a)
3. Derive equation (8.18) for the grating equation: