

Problem Sheet D

In ALL the questions below, you should provide appropriate comments on your answers.

A plasma-based XUV laser is formed from a plasma column 7.5 cm long and 200  $\mu\text{m}$  in diameter. The wavelength of the laser output is 4.31 nm with a line width  $\Delta\lambda/\lambda$  of  $10^{-4}$  and a pulse length of 5 ps.

1. Calculate the divergence, temporal coherence, longitudinal spatial coherence and transverse spatial coherence of the laser beam. Determine the number of transverse modes.

2. Compare the values you have obtained with those of a commercially available pulsed Nd:YAG laser working in the second harmonic (you will need to look up some parameters).

3. Given that the  $1/e$  path length of the radiation in material containing carbon is  $-0.1 \mu\text{m}$ , while in water it is  $-2 \mu\text{m}$ , discuss, as quantitatively as possible, the feasibility of using the x-ray laser of question 1 for holographic imaging of hydrated biological cells.

4. Look up the optical constants  $\epsilon$  and  $f$  at a wavelength of 4.31 nm for nickel (Ni) and lithium (Li). Then answer the following questions, all of which refer to this wavelength.

(a) Determine the critical,  $\theta_c$ , and Brewster,  $\theta_B$ , and angles for Ni and Li.

(b) Calculate the ratio of the s- and p-polarised reflectivities for both Ni and Li at  $\theta_c$  and  $\theta_B$ .

(c) Estimate, stating your assumptions, the maximum number of layer pairs of a Ni/Li periodic multilayer that would contribute to the overall reflectivity.

(d) A Ni zone plate is made with a diameter of 400  $\mu\text{m}$  and an outer zone width of 120 nm. Determine the first-order focal length, the first-order focal spot size (assuming a source size of 200  $\mu\text{m}$  at a distance of 1 m), the thickness of Ni required to give optimum efficiency, and the corresponding efficiency.

Answers (one copy), showing full working, must be handed in to Julia Kipparick by 17:00 on Friday 11 December 2009. You should **not** assume that a late submission will automatically be marked **unless** there is a medical or other extenuating reason for lateness, supported by an appropriate medical certificate or documentation.

Remember that you are being trained in research techniques; these include the ability to discuss problems with your colleagues. You are therefore encouraged to do this, before asking members of staff for assistance/hints. Remember, however, that the work submitted MUST be your own.