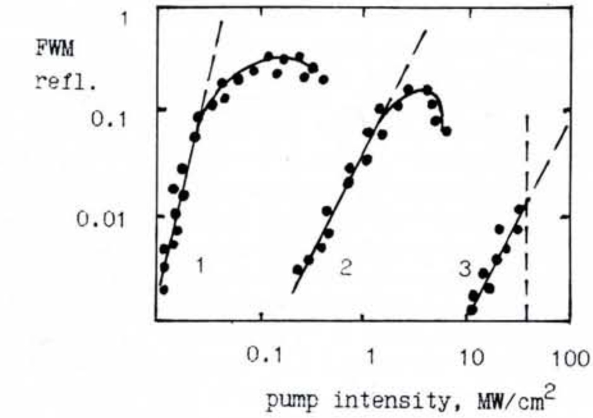

Fig. 3 — Phase conjugate reflectivity as a function of the pump wave intensity for InSb (1), InAs (2) and Ge (3) samples of 0.05, 0.11 and 1.0 cm thickness respectively. The vertical dashed line indicates the damage threshold of the samples for a CO_2-laser pulse length of ≅ 0.1μs [4].

The magnitude of $\delta\varepsilon$ is governed by the type of non-linearity and the characteristics of the non-linear medium as well as by the effective light wave intensity. In dielectrics and wide-gap semiconductors, this intensity is limited, as a rule, by optical damage to the material. In the narrow-gap semiconductors, the limiting phenomenon is non-linear absorption owing to the n-photon induced generation of electron-hole pairs. The cross-section for this is defined by the cross-section of the resonant transition between sub-bands of light and heavy holes in the valence band. That is why it is so large (≅ 10^{-15} cm^2). As a result, the growth of R with an increasing pump wave intensity in narrow-gap semiconductors reaches a maximum R_m determined by the non-linear absorption (see Fig. 3). If this is taken into account, R_m in the narrow-gap semiconductors becomes a characteristic property defined by the sample's non-linear susceptibility, the constant of non-linear absorption, and the coefficient of the linear absorption [4]. Calculations for the materials listed in the Table show that only for the semiconductors InAs and InSb is $R_m \geq 1$ at wavelength of 10.6 μm.

In addition to limiting R by FWM, non-linear absorption also has another important role to play. One of the fundamental causes for the deterioration of PC quality is distortion of the pump wavefronts by the self-focussing effect (Fig. 4). Non-linear absorption smoothes the transverse distribution of intensity for the pump waves, allowing a reduction in the self-focussing wavefront distortions. Numerical calculations demonstrate that FWM of a beam with a Gaussian transverse beam profile in a cubic non-linear medium having a non-linear absorption provides a PC quality of about 95% for $R \geq 1$. (In a non-absorbing medium, the PC quality is ≅30% *ceteris paribus*.)

Other important characteristics of the reflectivity are the range of the signal wave intensities (the dynamic range), the potential for polarization reconstruction, the spectral and spatial selectivity, *etc.* [4]. Most of these, however, are practically independent of ω, so they do not show any unique features in the mid-IR.

It can be concluded that phase conjugation in the mid-IR is sufficiently well understood that one can start to apply it in practical lasers and laser systems. This will be the main thrust of future activity in the field.

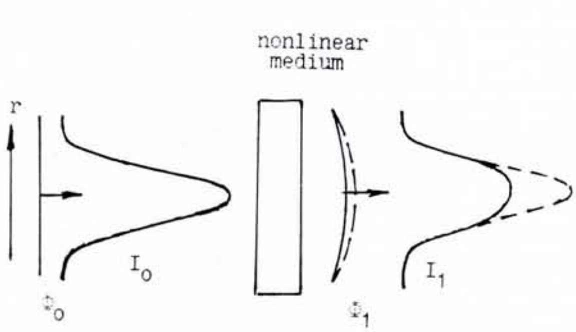

Fig. 4 — Schematic representation of the reduction of self-focussing wavefront distortion in a non-linear absorbing medium for a beam with non-uniform intensity profile. The dashed lines on the right represent the profiles of the intensity I and the phase ϕ for a non-absorbing medium.

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Beryllium Brings its Benefits

Before being shut down towards the end of 1989 for general maintenance and the replacement of a suspect toroidal field coil, JET produced discharges of record breaking quality, primarily as a result of the reduction in high Z impurities brought about by the installation of beryllium tiling and a flush of beryllium over the surface of the vacuum vessel. The results have triumphantly justified the conviction of the JET Director, Paul-Henri Rebut who was advocating as early as 1985 the provision of Be surfaces to help reduce contamination of the plasma. At the time, however, it was judged prudent to start with carbon tiles as they represented no health hazard. These certainly gave big improvements in performance over the high nickel surfaces, but contamination of the plasma with carbon was still a restricting factor.

The best individual figures that have been obtained now are a temperature, T, of 280 MK, a plasma density, n, of 4 × 10^{20}/m^3 and an energy confinement time, τ, of 1.8 s. The combined figure of merit, the product $Tn\tau$, for individual discharges has been pushed up to 6 × 10^{21} MK m^{-3} s, an improvement of a factor 2.4 compared with the best previous performances. This is within a factor 10 of the figure associated with ignition.

Originally set up as a 12-year project starting in June 1978, agreement for a three-year extension to JET has already been approved, but this will clearly not be sufficient to exploit fully the potential of the device. The Director is currently advocating the continuation of experiments on impurity control through 1992-1994 followed by tritium operation up to the end of 1986, by which time radiation damage is likely to have taken its toll of the main coils.

The present replacement exercise, scheduled to last nine months, will be instructive in giving experience on making a major breach in the vacuum chamber whilst working with partially restricted access — light radioactive contamination and exposed Be surfaces — and should allow a better appreciation to be made of the full range of problems that tritium operation will bring.