# Radial Strain Birefringence in UHP Diamond from Copeton, NSW

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The refractive index (RI) of diamond adjacent to a pressurized spherical inclusion is studied using the concept of deforming an isotropic glass sphere. The equation of an indicatrix is $(X_1/N_1)^2+(X_2/N_2)^2+(X_3/N_3)^2=1$where $N_i$ represent the RI. Applying a positive pressure to a single pair of opposed points on a glass sphere uniaxially deforms the glass sphere and yields a uniaxial negative indicatrix. A biaxial indicatrix is created for a triaxial-pressed glass sphere by summing three different uniaxial indicatrix and back substituting for the indicatrix of isotropic unstrained glass.

Young's modulus of diamond[1] decreases by 20% in the order {100}, {110} and {111}. Around the inclusion, this creates a biaxial-like but radial strain birefringence (RSB) which we model. A measured maximum RSB of 0.022 around a coesite inclusion under 35 kbar remnant pressure yields: $RSB_{100}$= 0.022, $RSB_{110}$= 0.020, $RSB_{111}$=0.0194. This RSB is about 10x expected for uniaxial strain in diamond[2]. The shell of radially strained diamond adjacent to the inclusion, allowing for symmetry, is divided into 48 hexoctahedral photoelastic sectors bounded by the diamond directions {100}, {110} and {111} projected through the centre of the inclusion. Within each sector, the RSB in the diamond represents the difference between the radial RI and the tangential RI (2.43, radial versus tangential strain[3] response built in), so the RSB of one sector is completely isolated from all other sectors. A RSB sector is modelled in three ways: 1) make RI vary in a linear way per degree between $RSB_{100}$, $RSB_{110}$, and $RSB_{111}$; 2) resolve the radial pressure into three non-orthogonal crystallographic directions, and vector recombine the resultant RSBs, producing a total RSB variation that is gently curved; 3) sum (non-orthogonally) three strained indicatrix for {100}, {110} and {111} to make the radial RI indicatrix. Note that only the portion of this indicatrix which falls within the particular sector is real, and the calculated optic axes (2V=47°) of the radially strained diamond lie outside the sector. In the complete hexoctahedral presentation, all models produce a maximum RSB centred on the {100} radial directions.

A linear fit of remnant pressure versus measured maximum RSB for inclusions in seven uncut Copeton UHP diamonds has residual error of 9%. Our RSB modelling shows this could arise from the inherent difficulty of achieving optimal viewing orientation in uncut diamonds.

**References**

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