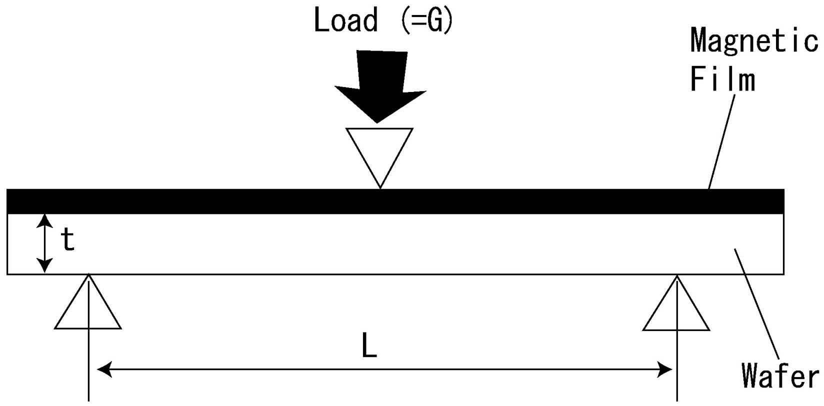
2.5 Measurement of magnetostriction



< Figure 6 Magnetostriction measurement >

Magnetic materials transform their shape in external magnetic field. The property called magnetostriction. Moreover, the magnetic characteristics of magnetic materials change when the magnetic materials are transformed by the external force.

The magnetostrictive anisotropy energy (=Es) of the magnetic material with external force follows:

$$Es = -\frac{3}{2}\lambda S\cos^2\phi$$

(In this equation, S is the internal tension in magnetic materials, φ is the angle between magnetization of magnetic materials and internal tension and Lambda is magnetostriction constant.)

Therefore, the total anisotropy energy Ea is shown by the sum of magnetocrystalline anisotropy energy Eu and magnetostrictive anisotropy energy Es.

$$Ea = Eu + Es = Ku\sin^2\theta - \frac{3}{2}\lambda S\cos^2\phi$$

(In this equation, θ is the angle between easy axis and magnetization, Ku is magnetocrystalline anisotropy constant.)

When the tension S parallel to the direction of hard axis, cosφ = sinθ. Therefore,

$$Ea = Ku\sin^2\theta - \frac{3}{2}\lambda S\sin^2\theta = \left(Ku - \frac{3}{2}\lambda S\right)\sin^2\theta = Ku'\sin^2\theta$$

Ku' is anisotropy constant in consideration of magnetostrictive anisotropy energy.

$$Ku' = Ku - \frac{3}{2}\lambda S$$

Therefore, the change of Hk with the change of tension is shown as follows.

$$\frac{dHk}{dS} = \frac{2}{Is} \cdot \frac{dKu'}{dS} = -\frac{3\lambda}{Is}$$

Now, let's think about the tension of thin magnetic film on wafer. Because the thickness of film is very thin compared with thickness of wafer, the strain (=ε) of film almost equals the strain of wafer. Therefore, the tension (=S) in the thin film is shown as follows:

$$S = e_f \cdot \varepsilon = e_f \left(-\frac{3LG}{2Wt^2 e_s} \right)$$

(In this equation, ef is Young's modulus of thin film, es is Young's modulus of wafer, L is length between fulcrums, W is effective width of wafer and G is applying load. In this device, L=88-24=64mm, W=98.5mm Is = 1.0 (T). This equation is given from an approximation of the equation that gives internal tension of pressed plate that is placed on two beams.)

Therefore, the magnetostriction constant is given as the following expression.

$$\lambda = -\frac{\Delta Hk \cdot Is}{3 \cdot \Delta S} = \frac{2Wt^2 e_s Is}{9Le_f} \cdot \frac{\Delta Hk}{\Delta G}$$

Note: The constant number are L= 64 (mm) , W = 98.5 (mm), Is = 1.0 (T)