Magnetostriction Calculations
Shb Instruments, Inc.

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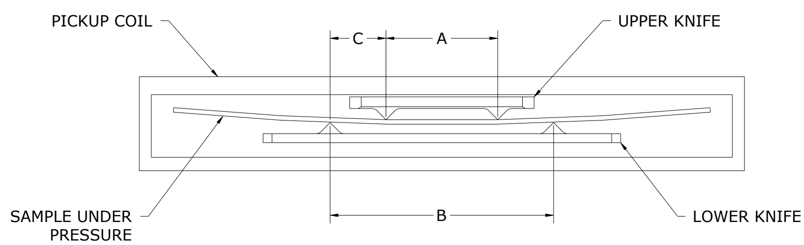
The mechanical layout of the knives in the Magnetostriction pickup is as follows:
(for Series C Mesa Magnetostriction pickups see separate document)

KNIFE DIMENSIONS

SAMPLE SIZE	UPPER KNIFE "A"	LOWER KNIFE "B"	Dimension "C"	Upper Knife Length	Lower Knife Length
3"	1.000 (2.540)	2.000 (5.080)	.500 (1.270)	2.375 (6.033)	1.625 (4.127)
4"	1.250 (3.175)	2.500 (6.350)	.625 (1.588)	4.000 (10.160)	2.500 (6.350)
5"	1.500 (3.810)	3.000 (7.620)	.750 (1.905)	4.188 (10.638)	3.125 (7.938)
6"	1.813 (1.813)	3.750 (9.525)	.969 (2.461)	4.750 (12.065)	3.940 (10.008)

Note: Dimensions are in inches. Dimensions in () are centimeters.



Values for Permalloy (NiFe) are used as an example.

For purposes of analysis we model this as a beam, with rectangular cross section, that is supported at the ends, and has force downward force P applied at two locations by the upper knife edges. The beam is of thickness T (the wafer thickness), and extends into the paper a distance B, which we approximate as the average of the lengths of the upper and lower knives (8.25 cm for 4” samples).

Reference texts show that the bending moment is constant in the area between the upper knives, and expressed as:

$M = -PC$

where C is the distance between the effective end of the beam and the upper knife edge, as indicated in the above drawing (1.588 cm for 4" samples).

The stress is found to be:

$\sigma = -PC\ [\ 6/(BT^2)]$

The strain is therefore:

$\varepsilon = (-PC/E_{Si})\ [6/(BT^2)]$

where E_{Si} is the Young's modulus for Silicon (1.1×10^{12} dyn/cm^2).

The change in H_K when the sample is stressed is known to be:

$\Delta H_K = [(3E_{NiFe}\lambda_S) / (M_S(1-\upsilon^2)]\ \varepsilon$

Where E_{NiFe} is the Young's modulus for NiFe, λ_S is the film Magnetostriction constant, M_S is the saturation magnetization of the film, and υ is the Poisson ratio for the NiFe film and the silicon substrate, which are assumed to be the same, and equal to 0.3.

Solving for λ_S we get:

$\lambda_S = [\Delta H_K / \varepsilon]\ [M_S\ (1-\upsilon^2)/\ (3\ E_{NiFe})$

M_S is approximately (10,000 Gauss) / 4π for NiFe, and can be correlated with the Bs (flux measurement in nanoWebers) done by the Shb instruments as follows:

Bs / 10 give the total flux in Maxwells (Φ).

We know:

$\Phi = (4\pi\ M_S)$ (cross-sectional area of sample inside pickup).

The cross sectional area is approximated as the thickness of the film (T), multiplied by the effective width of the sample (e.g. 4 inches = 10.16 cm) for a 4" round wafer.