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FEM Validation of a Single Degree of Freedom Model for Piezoelectric Energy Harvesters

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Ambient vibrations are present in different environments. Energy can be extracted from these sources by using piezoelectric energy harvesters, enabling these devices to obtain low-power energy.

Most ambient vibrations extend over a wide low frequency range. Therefore, the design of the cantilevers must be aimed at very low frequencies. This can be achieved by tuning the cantilever thickness and relative dimensions of the proof mass and cantilever beam. Analytical models were validated by FEM simulation methods, which allow for an optimal design.

The devices are aimed to replace low-power batteries, for that reason the total lengths of the devices should be preferable within one centimetre.

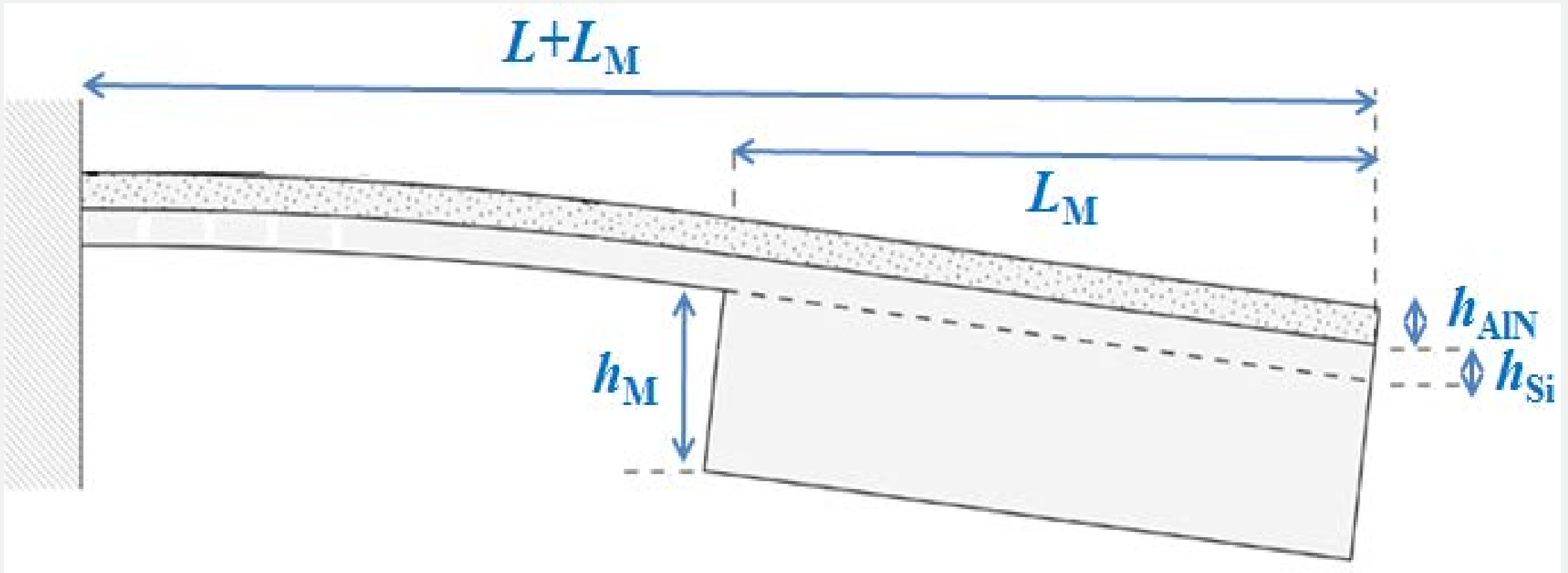

Figure 1. Schematic design of the cantilever used in the analytical and FEM calculations.

Device’s optimal dimensions

The optimal relative dimensions of the proof mass and the cantilever as well as the thickness of the cantilevers are studied in order to achieve the lowest resonance frequency.

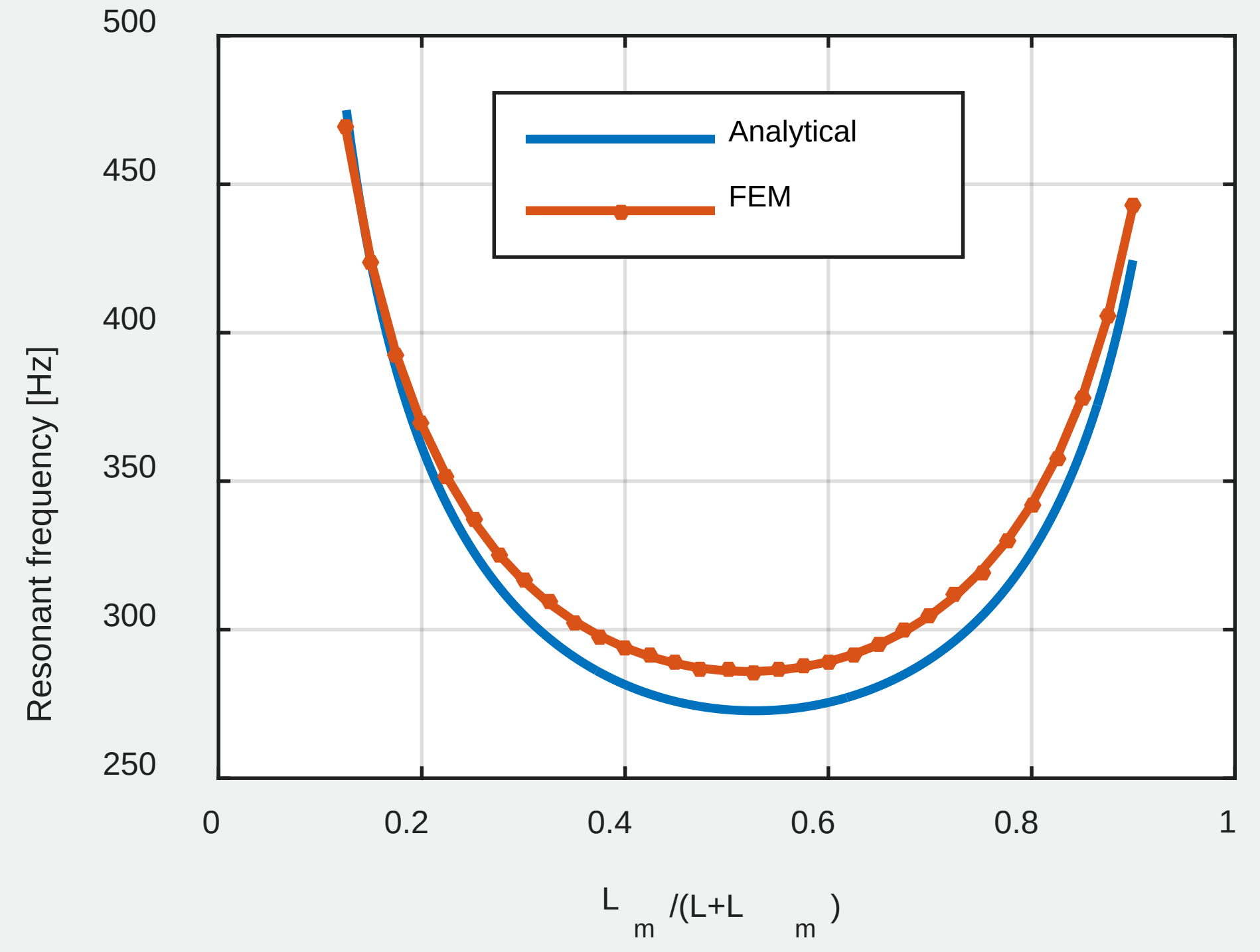

Figure 2. Resonant frequency as a function of ratio between proof mass length and beam length for both the FEM and analytical models.

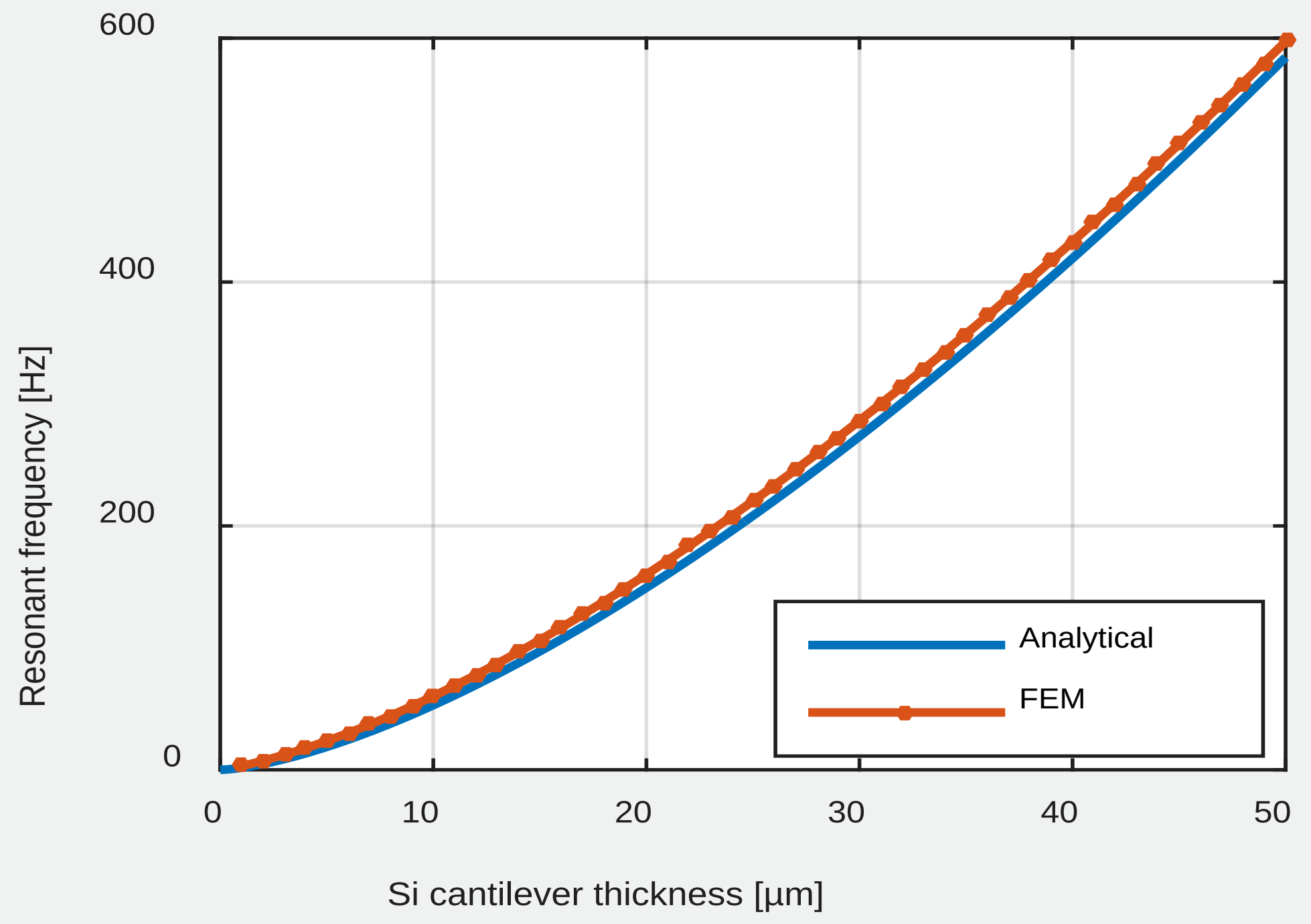

Figure 3. Resonant frequency as a function of cantilever thickness for both FEM and analytical models.

Piezoelectric material

The piezoelectric material Aluminium Nitride (AlN) is normally deposited via reactive sputtering, which is a time-consuming process. It becomes therefore important to determine how the thickness of the AlN layer affects the output power that can be harvested.

Fig. 4 shows the power versus the piezoelectric layer thickness, it can be seen that the power depends on the thickness until a certain value is reached. Beyond that value the AlN thickness does not affect the obtained power, being it constant over thicker layers.

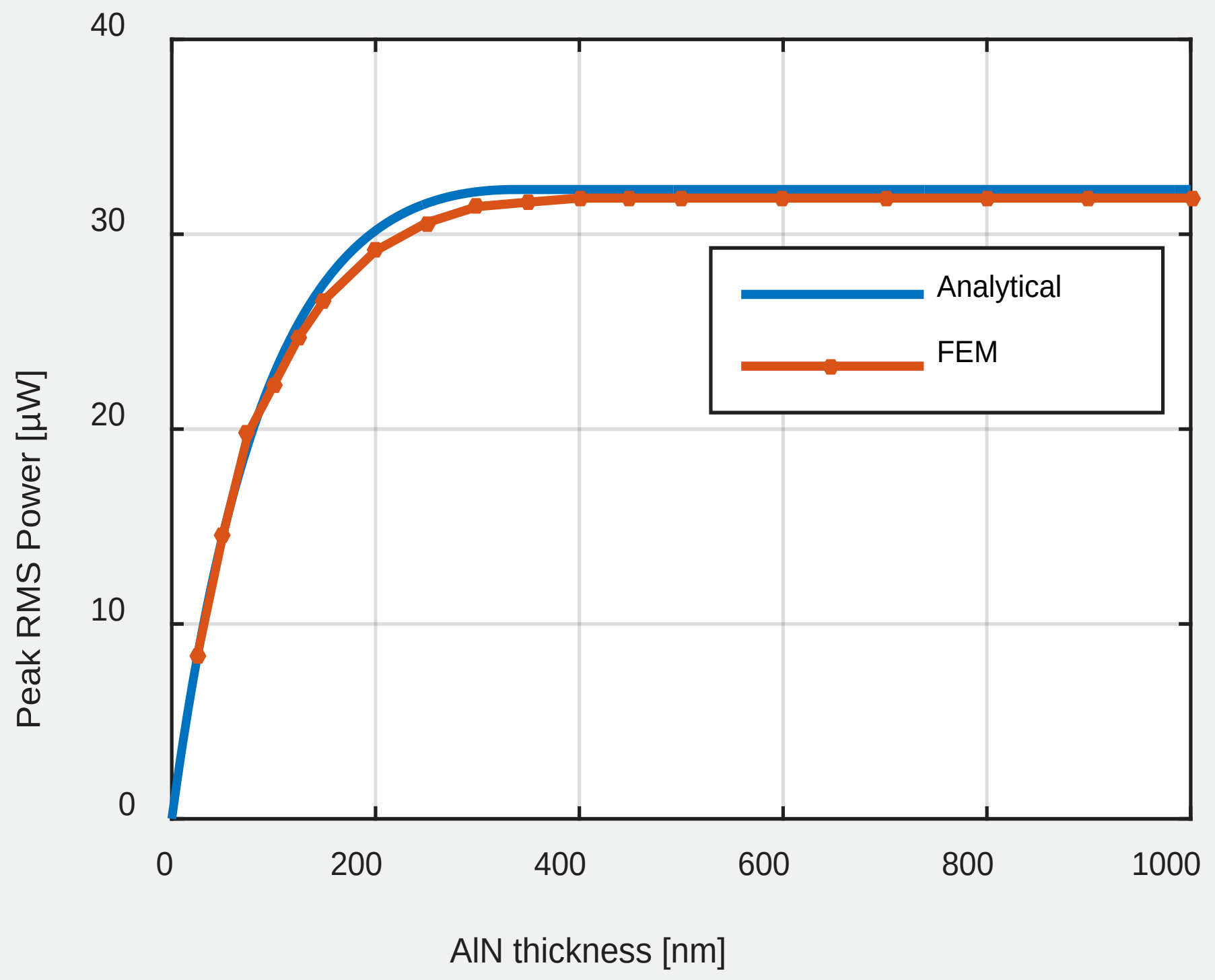

Figure 4. Maximum power obtained ffrom the device as a function of the AlN thickness for both the FEM and analytical models.