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MEMS ENERGY HARVESTERS BASED ON AEROELASTIC PHENOMENA

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This paper deals with the study of some of the classical aeroelastic phenomena in the fluid-structure interaction of piezolaminated beams at the microscale, with the aim of evaluating a possible application in the field of *Energy Harvesting* [1]. The performances of this kind of structure are critically assessed by considering the theoretical estimate of electric power generation on the basis of realistic microfluidic flows. The following aeroelastic phenomena are considered [2]: Vortex Induced Vibrations (VIV), Transverse Galopping (TG), Flutter Instability (F). The theoretical study has been based on reduced order models, obtained by applying the Rayleigh-Ritz method. A model with two and three degrees of freedom (dofs) has been used respectively for VIV, TG (dofs are transverse displacement and electric potential) and for F (dofs are transverse displacement, rotation and electric potential). The sectional behaviour of the beams has been represented by the theory of laminates, account taken of the piezoelectric coupling [3]. Special consideration has been devoted to the electrical circuit, to be connected to the piezoelectric beams in order to extract electrical energy [4]. Two types of circuit have been studied: only resistive electrical circuit (RC) and resistive-inductive electrical circuit (RLC). Preliminary analyses have been performed on cantilever structures (Fig. 1), in such a way to understand the real efficiency of a *flow energy harvesting* microsystem.

In the case of VIV, a better behaviour is obtained for fluids like water (with a high density) rather than others, such as air. The reason is twofold: first, the amplitude of the aerodynamic load is linearly influenced by the value of the fluid density; the second reason is linked to the lock-in phenomena [5]. In fact, the syncrhonization occurs when the vortex shedding frequency is close to the frequency of the micro-structure: the results show that, in the case of fluid like air, this phenomena occurs at very low Reynolds numbers, owing to a large value of kinematic viscosity. Low Reynolds numbers involve low fluid speed and low amplitude of aerodynamic loads. Conversely, the kinematic viscosity of water is an order of magnitude less than that of the air, thus achieving a more efficient *energy*

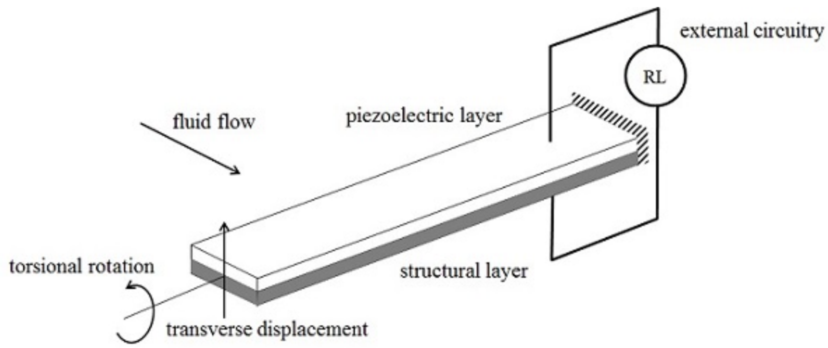

Figure 1: Scheme of the piezo-laminated cantilever beam considered in the present study

harvesting structure. The analyses also show that the solution with RLC coupled circuit exhibits a more efficient response in terms of electric power generation: this fact depends on the low value of the electro-mechanical coupling.

Transverse galopping and flutter represent instability phenomena, so the aim of the study is to evaluate how the piezoelectric coupling influences the critical flow speed. To this purpose, the Authors have used galopping coefficients and flutter derivatives reported in the literature for this kind of structure and for low Reynolds numbers. The results confirm that the electro-mechanical coupling increases the stiffness and the damping of the structure, and consequently increases the critical flow speed.

The preliminary simulations, carried out in the present study, allow for a deeper understanding of energy harvesting from fluid flow at the micro-scale. The achieved results will be used, in future works, in order to obtain optimized devices, possibly endowed with different and more complex shapes with respect to the simple cantilever considered herein.

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