Mechanisms of Effecting of Surface Stress on Output Parameters of Surface Acoustic Wave Devices

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Abstract - **In this paper reasons of surface stress are given, and interaction mechanisms of surface stresses and surface acoustic wave (SAW) parameters are described.**

Keywords – S**urface acoustic wave parameter, SAW, surface stress.**

I. INTRODUCTION

Most calculations, which are done before creation of SAW device, performed with values taken for solid materials. But surface of material has it's own parameters, which depend on way the machining was done [1]. Also film structure of SAW device is used often, and film properties are also different from properties which solid material has [2]. So for more precise calculations it is needed to have coefficients or formulas which can bring theory closer to practice, or at least understanding of this interaction process in future can lead to new engineering solutions.

II. SURFACE STRESSES

Crystal of material on its way to part of SAW device is involved in many processes, which are done to fit the crystal to the parameters which are dictated by the output parameters of SAW device. Each of this processes effects surface, or in our case it is better to say propagation medium of surface waves. In this chapter most affecting cases of this process will be considered.

Actually sawing crystal on wafer is most affecting processes, and all following actions will be performed to make its properties like solid material has. The first of such properties will be surface properties, because this part of material was most effected during sawing process and become totally unacceptable, a lot of changes happens, they lead to foliation of the surface. Due to this foliation next surface layers appear: relief layer, fissured layer, plastically deformed layer, strained layer. As it was researched by A. J. Slobodnik [3] presence of even tiny scratches (up to 0.15 μm) can lead to sufficient attenuation. Polishing process causes dual effect on surface. The positive one is that relief layer after polishing is sufficiently diminished. But due to material removal, and changes caused by pressure on the surface during polishing, stresses in plastically deformed and strained layers become more sufficient. This stresses lead to bending of the plate (Twyman effect), which is also unwanted changes.

If SAW device structure is multilayer then on surface described above will be piezoelectric layer spattered. In such case, except of stresses which are usual for films, new stresses will be added. They will be caused by stressed surface of substrate, on which new layers or films will be formed. So in such way domino effect can be observed. So in multilayer structure total stress can be counted as sum of each layer stress multiplied by layer interaction coefficient. This coefficient will very due to method of layer creation.

As it is known the waves in solids are nothing else but elastic strain of crystal lattice site. But as it was considered above the lattice on the surface of the material is not perfect, and has its own foliation. In each layer the impact will be different. In relief layer average density will be effected, what will effect the rest of the coefficients by-turn. Fissured layer effect can be described as transfer effect, cause in it there will be effects from both neighboring layers, but they won't be so sufficient as they are in relief layer and plastically deformed layer, because micro cracks will reduce deformation tension. Plastically deformed layer, strained layer will mostly effect the Poisson's ratio, shear modulus, Young's modulus etc. As it is known the wave velocity in solids depends on shear modulus and density of material. The surface wave is not an exclusion although it isn't so obvious as it is with bulk waves. Also the effect on other SAW parameters, such as electromechanical-coupling coefficient, temperature coefficient of delay, propagation number, can be counted through considered above Poisson's ratio, shear modulus, Young's modulus etc.

III. CONCLUSION

The effect of surface stresses on SAW parameters could be counted on theoretical phase of engineering. Theoretical calculation can be more precise thanks to the formulas which could describe interaction of surface stresses and surface acoustic waves. Also it can be useful for choosing the right materials or right mechanisms of SAW device creation. Understanding principles of this interactions is the first step to derivation of such a formulas. In further development it can give us dependence of SAW devices output parameters on surface stresses.

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