# The impact of temperature and mechanical stress induced by packaging mold on the accuracy of CMOS integrated LC oscillators

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*Abstract*— **In this paper a model of a CMOS integrated plate capacitor and the effects of thermal expansion due to the packaging induced mechanical stress is presented. Simulations show the average capacitance sensitivity of 0.462 [aF/K] over the temperature range between 0°C (273.15 K) and 175°C (448.15 K). Using this sensitivity in combination with Colpitss oscillator designed in A. S. Delke 2020 [1], the worst-case frequency error, induced by the mechanical stress of the packaging mold, is found to be 13.65 [ppm/K].**

## I. Introduction

Recent studies have been focusing on replacing the quartz crystal oscillator by a fully integrated CMOS LC oscillator. The associated benefits of this method are the lower cost, smaller size, lower component count and potentially higher reliability [2]. The biggest hurdle to overcome in designing such CMOS integrated oscillators is achieving high levels of stability and accuracy [3][4]. An extensive part of the research in this specific field, has been done on the implementation of temperature control circuitry to increase the stability and accuracy of the temperature dependent LC oscillator [1][4][5]. These studies have pushed the accuracy and stability to such an extend that the question arises if the effect of package induced mechanical stress is becoming a relevant pressing factor in making highly accurate and stable LC oscillators.

Most CMOS integrated circuits are encapsulated in plastic due to their compact and moisture resistant ability in combination with their relatively inexpensive price tag [2].
However, it is already proven that the packaging of a semiconductor chip induces mechanical stress on the die that leads to degeneration of matching and hence performance loss inside sensitive circuitry. Circuitry like LC oscillators or voltage reference circuits [3][6][7][8]. This degeneration of matching due to encapsulated packaging reduces the overall achievable accuracy and stability of the oscillator.
Nevertheless, the mechanical stress induced by packaging is not always a non beneficial side effect. In some degree, it can enhance the performance on the transistor level, in that case it is purposely applied as a low cost performance gain [9].

It has been shown that package induced mechanical stress is largely due to the mismatch in the Coefficient of Thermal Expansion (CTE in ppm/°C), between the packaging mold and the die, but also because of the mismatch of CTE inside the die itself [3][10][11]. Temperature variations during the fabrication process induces compressive and tensile stress inside the die due to difference in thermal expansion between the different material layers. This specific effect is modeled and simulated using a 3D model inside Comsol Multiphysics® in order to visualise the deformation due to the mechanical induced stresses.