

Advanced Fringe Analysis Techniques in Circuit Edit

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Introduction

Novel Fabry Perot [1] fringe analysis techniques for monitoring the etching process with a coaxial photon-ion column [2] in the Credence OptiFIB are reported. Presently the primary application of these techniques in circuit edit is in trenching either from the front side or from the backside of a device. Optical fringes are observed in reflection geometry through the imaging system when the trench floor is thin and semi-transparent. The observed fringes result from optical interference in the etalon formed between the trench floor (Si in the case of backside trenching) and the circuitry layer beyond the trench floor. In-situ real-time thickness measurements and slope correction techniques are proposed that improve endpoint detection and control planarity of the trench floor. For successful through silicon edits, reliable end point detection and co-planarity of a local trench is important. Reliable end point detection prevents milling through bulk silicon and damaging active circuitry. Uneven trench floor thickness results in premature endpoint detection with sufficient thickness remaining in only part of the trench area. Good co-planarity of the trench floor also minimizes variability in the aspect ratios of the edit holes, hence increasing success rates in circuit edit.

Bulk silicon removal and End-pointing

Through silicon circuit edit on a device begins with globally thinning silicon to approximately $100\mu\text{m}$. The global thinning is followed by local bulk silicon removal or trenching in up to $300 \times 300 \mu\text{m}$ area using a 20nA beam current at 30keV beam energy. The current technique reduces the trench etch rate by reducing the beam current and beam energy from (20nA , 30keV) to (4nA , 15keV). The beam energy and current is dropped once the fringe contrast on the optical image increases [3]. The timing of this decision is subjective in nature and depends on the user's experience level. For instance a new user tends to drop the beam current and beam energy at a higher remaining thickness of silicon compared to an experienced user. Due to the qualitative nature of this decision either the user can risk breaking through silicon and damaging the circuitry or the user can slow down the trenching speed, hence increasing the trenching time significantly. Furthermore, trench end-point detection depends on the ability to detect voltage contrast (VC) on n-

wells [3]; voltage contrast quality is related to user experience, system performance (good beam calibrations, beam energy and SE detector quality), die dopant levels and n-well size and density* (Fig. 1). A more robust end-point detection technique for trenching is necessary to overcome these dependences. Therefore to address all the issues mentioned so far a quantitative approach of in-situ remaining silicon thickness measurement is required. Absolute remaining thickness of silicon can be measured by using the optical beam of the OptiFIB system. Two in-situ thickness measurement techniques are discussed. The first technique for the thick sample regime measures the amplitude of the interference fringes as a function of time at a certain region and is discussed in detail in the section titled, "Absolute thickness measurement based on fringe contrast variation". The second technique for the thin sample regime uses two light sources having wavelengths λ_1 and λ_2 and the observed shift between their fringes which is discussed in detail in the section titled, "Absolute thickness measurement based on dual-wavelength technique".

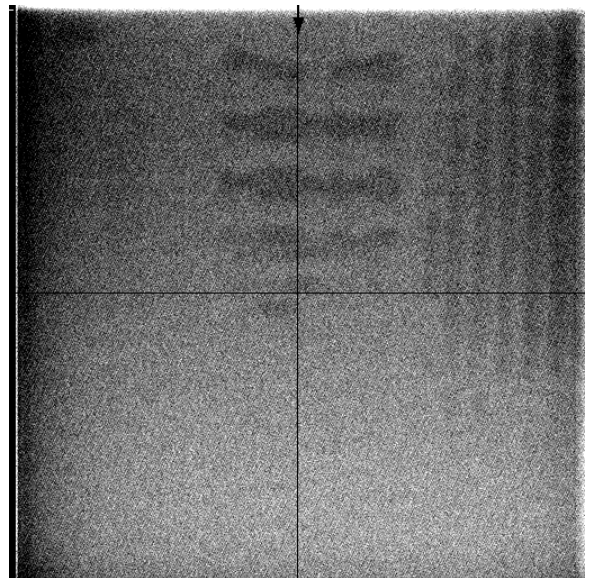


Figure 1: High density n-well image with excellent beam current calibration and yet n-wells are difficult to see.

* Detecting n-well contrast presumes a p-substrate. For an n-substrate, p-wells would be detected.