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# A Novel Method for Diameter Measurement of Silicon Single Crystal

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**Abstract.** Auto diameter measurement plays an important role in Czochralski method for silicon single crystals. In this paper, a novel approach based on concentric ellipses is proposed to measure the diameter of silicon single crystal. First, we analyze the concentric elliptical relationship between the heat shield and the meniscus in a captured image. Then, we further find the diameter of the crystal can be calculated by special geometric properties of concentric ellipses. According to this discovery, our approach is designed to measure the diameter of crystal in two stages. Compared to conventional techniques, our method doesn't apply a complex circle/ellipse fitting algorithm to every image during diameter detection, which makes it suitable for real-time applications. In addition, an ellipse edge filtering algorithm is used to improve the robustness of our system. Experimental results on synthetic images and real images demonstrate that our method is efficient, accurate and robust.

**Keywords:** silicon crystal, diameter measurement, concentric ellipses, geometric property, edge filtering.

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## 1 Introduction

Silicon single crystal is the mainstay of the microelectronic and photovoltaic industries. Among all techniques of manufacturing silicon single crystal, Czochralski (CZ) method has proved to be one of the most important economically viable crystal growth techniques because it has many advantages such as fast growth speed, high purity and large diameter [1]. In the CZ method, a quartz crucible storing polycrystalline silicon is first located in a crystal puller. By heating the crucible to a predefined temperature, the raw material is melted and forms a silicon melt in the crucible. Then a monocrystalline seed is immersed into the silicon melt [2]. As the seed is slowly pulled upwardly while being rotated in a predetermined pulling speed



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