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# Investigations of defects in ceramic tiles using Double Exposure Digital Holographic Interferometry (DEDHI) technique

Prashant P. Chikode[a,*], Rajiv S. Vhatkar[b], Sandip D. Patil[c], Vijay J. Fulari[b]

[a] Department of Physics, Jaysingpur College, Jaysingpur, M.S., 416101, India
[b] Department of Physics, Shivaji University, Kolhapur, M.S., 416004, India
[c] Department of Physics, Devchand College, Arjunnagar, M.S., 591237, India

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ABSTRACT

Glazed ceramic flooring tiles have a protective layer that rests over the material, making them impervious to water and stain penetration. A typical defect found in the ceramic tile is delamination. This paper describes the problem of detecting delamination and defects of typical ceramic tiles by using Double Exposure Digital Holographic Interferometry (DEDHI), as a non-destructive technique. The specimen tiles of different qualities (defected) having dimensions 10 cm × 12 cm are used as the sample tiles. These tiles are subjected to mechanical and thermal stressing and their double exposure digital interferograms are recorded. Digital reconstructed images show various fringe patterns. It is found that the defected samples show the irregularity in the fringe patterns and the shape of the fringes changes accordingly the defect, crack and debonds present in the samples. The compared fringe patterns, with fringe patterns of high quality on ceramic samples give reasonably interesting results.

## 1. Introduction

Silica and ceramic based materials are widely used in industry as well as in construction of buildings all over the worlds. Ceramic materials, which include monolithic ceramics and ceramic-matrix composites, have been identified as potential candidates for high-temperature structural applications because of their high-temperature strength, light weight and excellent corrosion and wear resistance [1]. In order to encourage the expanded application of engineering ceramics, the use of appropriate non-destructive evaluation approach is critical to effective process control and the assurance of high-quality products and reliable performance in service [2–5]. There are many methods such as pulsed tomography, radiography, liquid penetrant method, ultrasonic inspection etc., and many acoustic methods were reported for the non-destructive testing of ceramics. But these methods are difficult and expensive. Hence there is wide scope in this field to use a method which is cost effective and easy to implement.

As ceramic materials are widely used in space shuttle tiles, thermal barriers, high temperature glass windows, fuel cells glassware, windows, pottery, corning ware, magnets, dinnerware, ceramic tiles, lenses, home electronics and microwave transducers, it is necessary to study the strength and capability of these materials by using suitable methods. Minor cracks and defects plays important role in these applications. It is well known that double exposure holographic interferometry (DEHI) technique is a well-established optical method where two image holograms are recorded before and after an object's deformation. DEHI measures displacement maps that can be used to determine the surface deformation [6,7], Young's modulus [8,9], Poisson's ratio [10], thermal expansion coefficient [11], diffusion coefficient [12,13], thickness of thin films [14–17] etc. In recent years, DEHI technique has received

* Corresponding author.
*E-mail address:* prashantchikode@gmail.com (P.P. Chikode).

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# Determination of Young's Modulus of Silica Aerogels using Holographic Interferometry

Prashant P. Chikode [a], Sandip R. Sabale [b] and Rajiv S Vhatkar [c]

*a: Department of Physics, Jaysingpur College, Jaysingpur,Jaysingpur- 416 101, Maharashtra, India.*
*b: Department of Chemistry, Jaysingpur College, Jaysingpur,Jaysingpur- 416 101, Maharashtra, India.*
*c: Department of Physics,Shivaji University, Kolhapur- 416 004, Maharashtra, India.*

[a] Corresponding author:prashantchikode@gmail.com

**Abstract:** Digital holographic interferometry technique is used to determine elastic modulus of silica aerogels. Tetramethoxysilane precursor based Silica aerogels were prepared by the sol-gel process followed by supercritical methanol drying. The alcogels were prepared by keeping the molar ratio of tetramethoxysilane: methyltrimethoxysilane: H2O constant at 1:0.6:4 while the methanol / tetramethoxysilane molar ratio (M) was varied systematically from 12 to 18. Holograms of translucent aerogel samples have been successfully recorded using the digital holographic interferometry technique. Stimulated digital interferograms gives localization of interference fringes on the aerogel surface and these fringes are used to determine the surface deformation and Young's modulus (Y) of the aerogels.

**Keywords**: Aerogels, Holographic interferometry, Mechanical stressing, Surface deformation

## INTRODUCTION

Silica aerogels are highly porous (> 98%) [1] nanostructured materials with the bulk density as low as 0.02g/cm$^3$ and composed of as low as 0.2 % microscopic strands of silicon-dioxide as a tenuous web. But due to the high porosity and small solid content, determination of various mechanical properties of silica aerogels is a major challenge. Efforts have been made in the past to use non-destructive techniques like sound velocity measurements through aerogels[2, 3]. But there are no reports available on the use of digital holographic interferometry for the determination of mechanical properties of the aerogels. Even though the aerogels have very low densities (~ 0.05 g/cm$^3$) and very low Young's modulus ($10^6$-$10^7$ N/m$^2$), aerogels behaves as linear elastic materials [4, 5].

Holographic interferometry has been widely accepted as a viable tool for non-destructive testing of materials. It permits the qualitative and quantitative study of minute changes in object contours [6, 7]. Currently, new techniques are also available to analyze the interference fringes using high speed computers and charge coupled device (CCD) cameras and it is possible to record the digital holograms of aerogel samples with such a device [8-11].

We report here the use of Digital holographic interferometry [12], to study the surface deformation of mechanically stressed aerogel samples In this technique, the stressed state of the sample is compared with its unstressed normal state, which causes interference fringes to localize on the object. From the study of interference fringes, information about object deformation can be obtained with very high precision [13, 14]. As this technique is sensitive to the deformation of a sample on the order of the wavelength of the source (He-Ne laser, wavelength $\lambda$~6328 A), application of a small stress can give rise to interferometric fringes and hence the sample under test remains intact, reusable and crack free.

The paper reports the experimental work on digital double exposure holographic interferometric technique to study the surface deformation of silica aerogels, due to given variable mechanical loading.

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