Available online at www.sciencedirect.com

ScienceDirect

Procedia Structural Integrity 8 (2018) 220–226

Structural Integrity Procedia

www.elsevier.com/locate/procedia

AIAS 2017 International Conference on Stress Analysis, AIAS 2017, 6-9 September 2017, Pisa, Italy

Electro-mechanical endurance tests on smart fabrics under controlled axial and friction forces

Giorgio De Pasquale[a], Andrea Mura[a]*

[a]Department of Mechanical and Aerospace Engineering, Politecnico di Torino, corso Duca degli Abruzzi 24, Torino, Italy

Abstract

The design, building and validation of machine for endurance tests on fabrics are described in this paper. The system is addressed to the reliability testing of smart fabrics with electrical conductivity. The development of e-textiles, in fact, requires innovative test benches for the evaluation of performances decay with load cycles accumulation; the proposed system is able to monitor the electro-mechanical parameters of fabric sample in the same time in order to support industrial development and predict failures on final applications.

Keywords: electro-mechanical reliability; lifetime; experimental mechanics; wearable sensing

1. Introduction

Smart fabrics consist in textiles featuring woven electronics and interconnections. The mechanical properties of smart fabrics, in terms of flexibility and strength allow creating many applications of wearable electronics that cannot be realised with other existing electronic manufacturing processes.

The rapid evolution of wearable electronic drives the grown interest in smart textiles Stoppa et al. (2014) and many applications have already been developed, in different fields. As some examples, in medical and biomedical many wearable devices have been developed: electrocardiogram (ECG) electrodes Cho et at. (2011) , electromyography (EMG) Linz et al. (2007) , and electroencephalography (EEG) Löfhede et al. (2010), temperature measurement

* Andrea Mura. Tel.: +39 011.0905907.
E-mail address: andrea.mura@polito.it

10.1016/j.prostr.2017.12.024

Sibinski et al. (2010) . Other applications consist in shape-sensitive fabrics combined with EMG sensing used to perform muscle fitness Meyer et al. (2006), functionality, or assistive technology by radio frequency (RF) Black (2007).

Sensors integrated into fabrics have been used to detect specific environmental or biomedical parameters Coyle et al. (2010), and fabrics containing luminescent elements have been used for biophotonic sensing Omenetto et al. (2013). In electronics and telecommunication smart fabrics find application as electromagnetic shields Aniołczyk et al. (2004) , but also as distributed body-worn communication system Ouyang et al. (2008) and wearable antennas Wang et al. (2013), Salonen et al. (2003) . Another interesting application consists in human interface elements De Pasquale (2015), De Pasquale et al. (2016).

Dedicated fabrics have been developer for the energy generation and storage Vatansever et al. (2011), using piezoelectric Edmison et al. (2002), De Pasquale et al (2013), De Pasquale (2016) or photovoltaic devices Bedeloglu et al. (2009). Integrated micro electro mechanical systems (MEMS) De Pasquale et al (2009a), Ballestra et al. (2010), De Pasquale et al. (2009b), De Pasquale (2009) are also finding application in this field.

Despite the fast development of smart textiles manufacturing, the characterization procedures and design standards to certificate the electro-mechanical reliability of final products have not been developed and established and exhaustive test procedures and predictive models able to determine the combined electrical and mechanical reliability of fabrics are still not available.

Although many standard tests are available for traditional fabrics, they are not fully relevant for smart textiles where the electro-mechanical coupling is fundamental.

Actually, smart fabrics when worn are subjected to variable mechanical loads and wear that may cause failure in electronic connections, therefore the electrical continuity must be guaranteed during the whole life of the smart clot. Only few works concerning mechanical characterisation may be found in the literature, consisting in washing tests of ECG electrodes Hoffmann et al. (2007) and relaxation tests of conductive knitted fabrics for breathing sensors Qureshi et al. (2011), Atalay et al. (2013).

Therefore, comprehensive procedures and test methods are required to satisfy the design requirements of advanced applications involving smart fabrics.

The aim pf this work is to propose a test procedures where the sources of failure can be controlled and combined together to show cross-talk effects such as between load and wear cyclic loads and current flow, etc.

In particular in this work a novel test rig and the related experimental procedure to validate performances and reliability of smart fabrics under fully controllable conditions is presented.

The testing machine has been designed and a prototype manufactured. The test rig allows accelerated life tests with controlled conditions by coupling the effects of cyclic loadings equivalent to operative conditions, wear effect and electricity flow.

Nomenclature

D_c	duty cycle
f	friction coefficient
F	tensile force
F_0	axial preload
F_f	friction force
F_{max}	maximum force magnitude
h_0	clamp height
K	springs stiffness
L	sample length
L_0	clamps distance
v1	rotation speed
Δl	springs elongation
θ_a	active phase