

Piezoelectric motors for nano-engineering and metrology

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Principal Investigator:

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Project Objectives:

To investigate critical design parameters for piezoelectric motors in engineering applications

Investigate fabrication techniques for, and properties of, piezoelectric motors.

Build a piezoelectric micromotor of less than 2mm diameter and assess its performance.

Project Summary:

The project was conceived to address the issue as to whether piezoelectric ultrasonic motors could be developed for use in two main areas of application: nanotechnology, specifically the use of motors in nanopositioning applications, and microsystems. Piezoelectric motors use a ferroelectric ceramic element to excite ultrasonic vibrations of an appropriate type in a stator structure. A schematic representation of this is shown here: (Include reference to moving image). The elliptical movements of the stator are converted into the movement of a slider pressed into frictional contact with the stator. The consequent movement can either be rotational or linear depending on the design of the structure. There has been intense interest in Japan in their potential industrial applications and Canon, Shinsei, Seiko and Matsushita have all brought out products based on such motors. By contrast, interest in Europe was relatively slow to take-off and there has not been much work reported from the UK. By far the greatest proportion of the work reported has been on what will be referred to here as "macro-motors" where the maximum linear dimension of the motor is of the order of 10mm or more. One of the potential areas for application of these motors, taking advantage of their high acceleration, good frictional holding characteristics etc, is in positioning applications and at least one of the products on the market offers nanometric positioning accuracy with clear applications in the field of engineering nanotechnology. However, there is also growing interest in the area of microsystems and there is the potential for applying the technology to making micromotors, where the dimensions are in the millimetric range or lower. Such motors would have applications in the field of micro-robotics, machines-on-a-chip etc where their constructional simplicity would give them major advantages at the micro-scale over electro-magnetic (E/M) motors while they should be able to generate torques which are orders-of-magnitude greater than electrostatic (E/S) motors. The project accordingly followed the following methodology:

A study and assessment of travelling wave macromotors.

- The investigation of a novel standing wave motor using the radial mode of a ceramic disk with flexensional displacement amplifiers. (This was not in the original proposal but emerged as an original invention during the project.)

- The fabrication and assessment of a travelling wave micromotor design. A full description of the piezoelectric motor development is given on the accompanying site (<http://www.nanotek.org/piezomotorreport.html>). It includes the development of:
 - a. A B08 mode "macromotor"
 - b. A motor using the flextensional amplification of the radial mode of a ceramic disc
 - c. A miniaturised B0m mode motor

The research achievements of the project can be summarised as follows:

- Studied and developed the technology for making and driving piezoelectric TWUM in the 80mm diameter size range. This has included the optimisation of the piezoceramic and stator material choice, methods for surface preparation, ceramic electroding, ceramic/stator bonding methods, friction layers and high voltage/high frequency driving circuits.
- Developed a novel edge-supported membrane TWUM stator design which possesses good performance characteristics and can be scaled down to form a micromotor structure. This has excellent characteristics for precision positioning applications.
- Developed a novel, efficient and potentially very low cost motor design based on the use of the flextensional amplification of the vibrations of a piezoceramic disk, coupled to an elastic-fin driven rotor. This has been patented.
- Developed the designs, masks and fabrication techniques for a B02-mode piezoelectric TWUM micromotor exploiting a PZT thick film. The first prototypes of this motor have been fabricated and tested and shown to possess efficient piezoelectric coupling. A follow-on project on this design has been funded by EPSRC (GR/N34017: Piezoelectric microactuators for smart micro-air vehicles)

Project Collaborators:

BAE SYSTEMS, Morgan Matroc, Renishaw, Cetehor (France), Oxley Developments, Mr. Roger Feneley, NPL, Cedrat Recherche (France), KTH Sweden

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