# Spike: A Tangible Interface for Etching Audio Graffiti

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## ABSTRACT
We describe Spike, an actuated stylus that physically etches music into architectural surfaces and reads it back. Spike gives physical form to digital music and transforms the user's architectural surroundings into a sounding board and analog storage medium. Through Spike, we introduce a new form of graffiti that augments the expressiveness of traditional graffiti.

### Keywords
Graffiti, music, tangible interface.

## INTRODUCTION
Our cities are the most dramatic embodiment of the seismic cultural forces that shape our age. They form a crisis point of violent conflict where competing commercial, industrial, and political forces converge and from the immense pressure rises the cityscape, a vast tumultuous surface where humanism must continually defend its right to be, to occupy space. Michel de Certeau has suggested that the cities act as texts written in the paths along which its residents move [1]. In this sense, Graffiti artists are defenders of humanistic values, challenging the places where the human myths and narratives can be written by challenging conventional notions of property ownership and use.

Graffiti, as we currently know it, began in New York City in the early 70's. Originally, "writers" would simply inscribe surfaces with their signatures, but as Graffiti became increasingly popular, artists developed much more elaborate styles or "tags" [2]. The art of Graffiti, however, has always been relegated to the visual representation. Spike is an effort to expand the potential expressiveness of Graffiti and to make it available to artists whose work is not visual in nature. We can envision scenarios where DJ's inscribe their mixes to the walls of record stores or where Graffiti "taggers" accent their marks of identity with verbal manifestos.

## RELATED WORK
### Nam June Paik, Random Access Music
In 1963, Artist Nam June Paik assembled a music exposition which deconstructed current recording and playback technologies and made them the center piece for audience collaborative composition. One piece was made up of various segments of magnetic tape attached to the wall and a hand held sound head that audience members could use to run along the tape to produce their own compositions. The compositions were, of course, more than just the simple playback of the material on the magnetic tape, since it was possible for composers to move at varying speeds, in reverse, or even across various segments [3].

### Scratchiti
In the late 80's, New York's Metropolitan Transportation Authority began an effort, colloquially known as the Clean Train movement, to combat graffiti on subway cars [2]. While the effort met with success, it also tried to simultaneously address the issue of broken glass by replacing all train windows with shatter resistant plexiglass [5]. It did not take long for writers to realize that the new windows could be scratched and a new form of graffiti began to appear as tags were etched into the new windows. Much to the disappointment of the MTA, the scratches proved more permanent than aerosol paint.

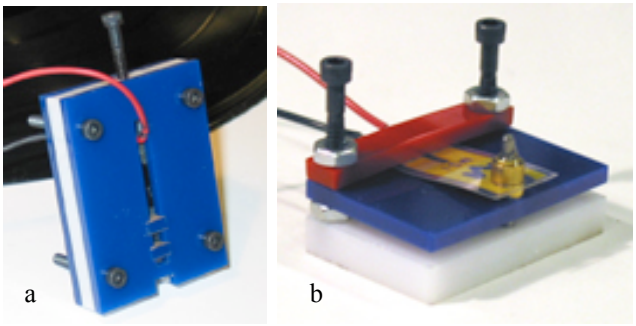


**Figure 1. Spike writer (a) and reader (b).**

## IMPLEMENTATION
### Writer
Similar to that of a vinyl recording, Spike engraves a groove with the depth of the groove related to the amplitude of the audio signal. In order to do this, the device requires an actuated cutting tip. The cutting tip selected for the first prototype was a steel cylinder sharpened to a point, similar to an engraver's awl. The cutting tip has to be removable as different tips may be required for different surfaces, such as diamond tipped blades for glass and heated tips for hard plastic.

The cutting tip needs to be linearly actuated with micron accuracy. The actuated must not be subject to inertial forces, so a standard dc motor probably will not work. The actuator must have enough force to cut into the surface. Lastly, the actuator must respond fast enough to transducer signals in the audio range of up to 20 kHz. A multilayer piezoelectric stack [4] was chosen that fits these parameters. A cylinder to hold the cutting was attached to the actuator

using epoxy. The cutting needle could then be inserted and removed when necessary.

The actuator cutting assembly was then mounted in a physical structure intended to be held and pressed flat against a surface, pressing the cutting tip into the surface to be engraved and holding it at a specific depth relative to the surface. This depth can be adjusted using a set screw depending on the surface being engraved into. The assembly is shown in Figure 1(a). It may be necessary to add a spring or other source of force to the assembly to make sure the needle stays firmly against the surface. Two additional but non-actuated cutting tips are added to the assembly on either side of the engraving tip. These are used to cut registration lines into the surface to allow easier tracking of the groove upon playback.

### Reader

Although a piezoelectric stack can be used both as an actuator and as a sensor, the required force to engrave the signal is much greater than the force generated when it is ran over the groove in order to play it back. A thinner, smaller piezoelectric element, as shown in Figure 1(b), was used as the position sensor to read back the signal when ran over the groove. A needle was attached to this element, and it was encased into a new physical assembly that holds it at the proper depth of the groove. The playback assembly also has two extra needles that ride in the registration grooves and keep the playback needle in the audio groove.

## CONCLUSION

The art of graffiti has a strong history of artistic expression and political activism behind it. However, the static nature of traditional graffiti severely limits the expressive power of graffiti artists. We seek to amplify that power with Spike so that users can communicate more of themselves or their beliefs to other users.

We also hope that the interactivity Spike brings to graffiti, that the manner in which a user reads back an audio groove affects the playback, will engage a larger audience than that of traditional graffiti.

Despite the prevalence of graffiti in cities around the globe, many still regard it as nothing more than rebellious and destructive acts of vandalism. With this project, we aim to undermine this view by showing that graffiti can be a valid and effective means of communication in and of itself.

## FUTURE WORK

In the future, we hope to combine writing and reading into one device either by mechanically coupling the two piezoelectric elements to a single cutting/reading tip, or by finding a new element that is a compromise between the reading and writing requirements.

Furthermore, our current design for Spike works under constrained conditions and only on a limited variety of materials. Future implementations should achieve greater robustness on a wider array of surfaces. We should also strive to reduce costs to keep Spike accessible to the general public.

Other directions left to explore include adding a built-in synthesizer to Spike and supporting multi-track etching to play back tracks in stereo and to promote collaboration among users.

## ACKNOWLEDGMENTS

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