Electronic Supplementary Information (ESI)

A Library of Large-Scale Surface Patterns Induced by Flame on Elastomers

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WRINKLE WAVELENGTHS WITH DIFFERENT FLAME OXIDATION TIME

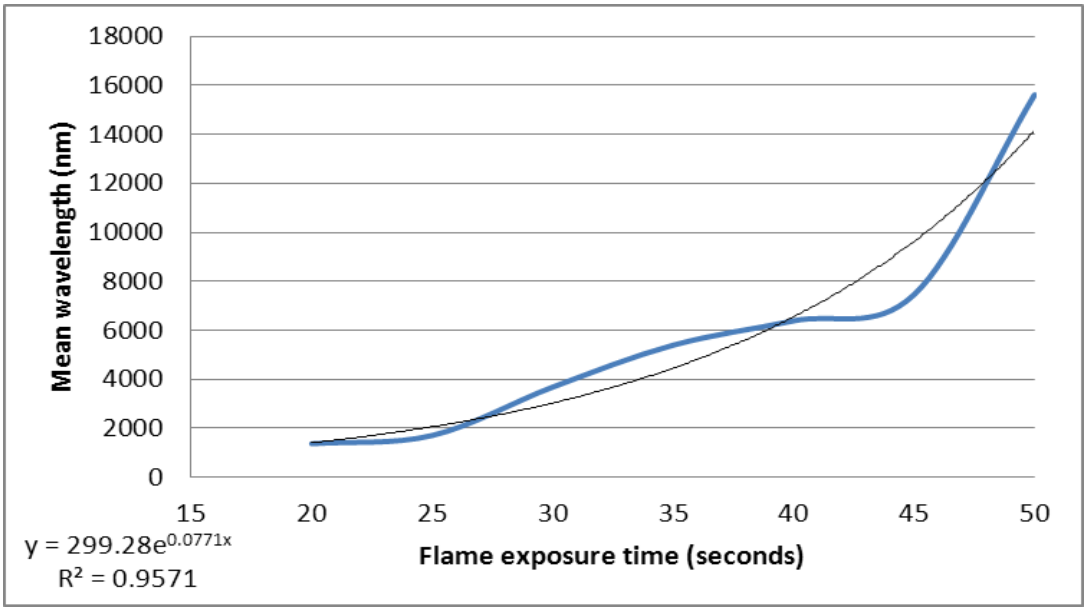

Figure S1. Characterization of the mean wavelengths of surface induced wrinkle patterns vs. flame exposure time. Flame exposure height above the flame: 0.5 cm. Stretching strain: 25%.

Due to the high variability of Bunsen burner outputs and laboratory environments, results will vary. The trend of the wavelengths is an important reference for generating specific surface wrinkle spacing. Also note that exposure times under 20 seconds produced inconclusive data and exhibited few surface changes. Exposure times greater than 50 seconds resulted in tearing failures of some PDMS samples. Therefore the data for exposure times greater than 50 seconds were excluded from the mean values along with data from exposure times under 20 seconds. Greater exposure times resulted in comparable crest lengths, but elongated trough lengths. Typically the samples maintained a similar trough and crest length under 40 seconds exposure. Longer exposure times also introduced more surface cracks and cloudiness. The trend line of the mean surface wavelengths followed an exponential curve with an R^2 value of 0.9571.

WRINKLE HEIGHTS WITH DIFFERENT FLAME OXIDATION TIME

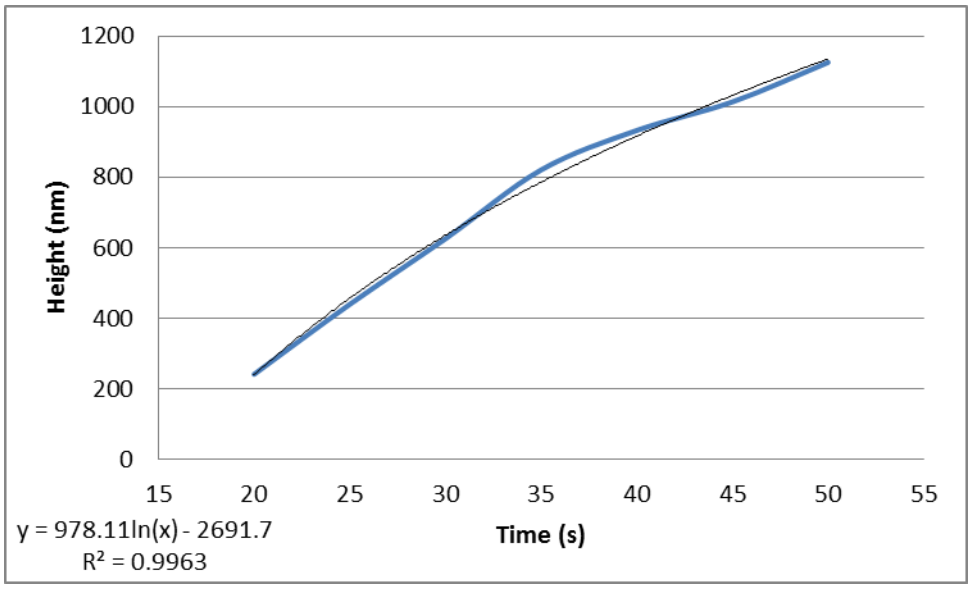

Figure S2. Characterization of the mean wrinkle heights vs. flame exposure time. Flame exposure height above the flame: 0.5 cm. Stretching strain: 25%.

Again, the variability of Bunsen burners allows for varying results. The exeriment was performed with a moderately low heat. Samples with no regular patterns were excluded from the data set. It should be noted however that irregular patterns did produce significantly larger wrinkle heights with elongated wave troughs but showed varying wavelengths. As with Figure S1, the data below 20 s exposure showed inconclusive data and the data above 50 s exposure were mostly burned samples. As the exposure time increased, the heights of the wrinkles also increased. Areas of samples began to burn at approximately 40 s exposure. Samples within the range of 40 s -50 s exposure produced larger wrinkle heights but less acurately adopted intended wrinkle patterns and wavelengths. The optimum range for pattern integrity was observed at exposure times from 25 s- 35 s.

FLAME ON PDMS WITHOUT STRAINS

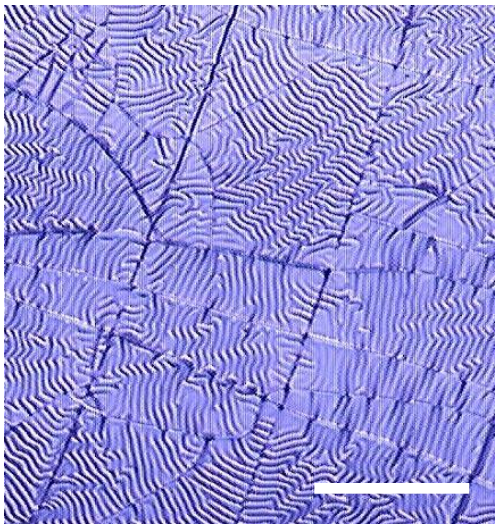

Figure S3. Optical image of a PDMS surface with an exposure to flame for 30 s without stretching and bending strains on PDMS. Scale bar: 100 μm.

Compared to PDMS elastomers that were exposed to flame with a surface strain, this sample was highly randomized and only affected by the compressive and tensile forces that were induced from the polymer expansion due to heat. The result was an unorganized pattern of surface wrinkles comparable to the patterns obtained through the methods of the experiment. Typically the samples exhibited surface cloudiness when exposed to flame but not the prismatic effect seen in the stretching methods. As seen in the sample, cracking releases surface strains. The wrinkle patterns roughly follow the array of cracks with a smaller scale order unique to each area. Flame oxidation creates surface patterns regardless of imposed surface strain.

SIMULATANEOUS RELEASE OF VARYING STRETCHING DIRECTIONS

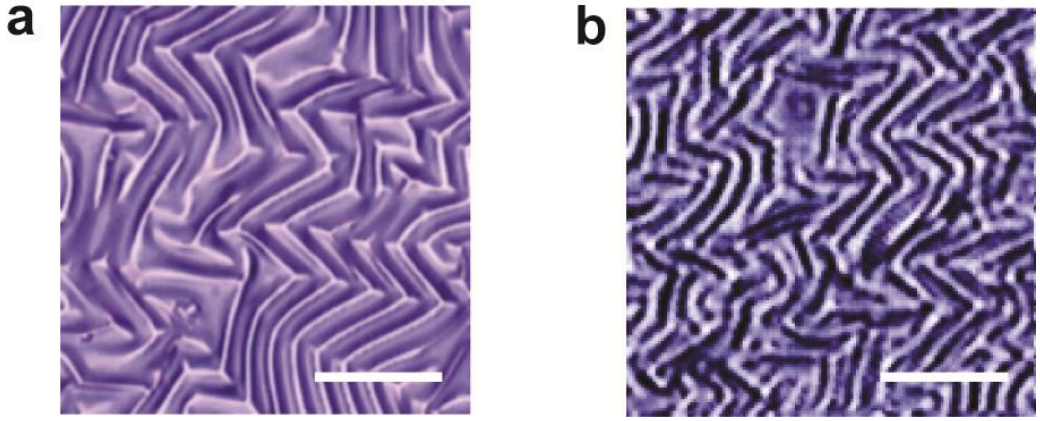

Figure S4. Optical images for wrinkle patterns with stretching/releasing the PDMS film simultaneously with **a.** 3-directional strains, and **b.** 4-directional strains. Strain in each direction: 25%. All scale bars: 20 μm.

The most pronounced effect was seen on the biaxially stretched samples when released simultaneously. The typical patterns changed from highly organized, to randomized patterns. The observed effect was not considerably distinct compared to a sequentially released sample. An element of randomization was introduced to the typical patterns from sequentially releasing the sample. The integrity of the original patterns the sequential releasing method were mostly maintained. Due to the highly randomized patterns observed in an 4 directionally stretched sample that was sequentially released, identifying the introduced randomized element was difficult. Typical patterns exhibited on the surface of 4 directionally stretched PDMS for both sequential and simultaneous release methods were similar in structure patterns and properties. Larger samples may produce different results due to the amount of strained areas. Also note that the simultaneous release method also resulted in more surface cracks in most cases.

DIFFERING ANGLES OF BENDING

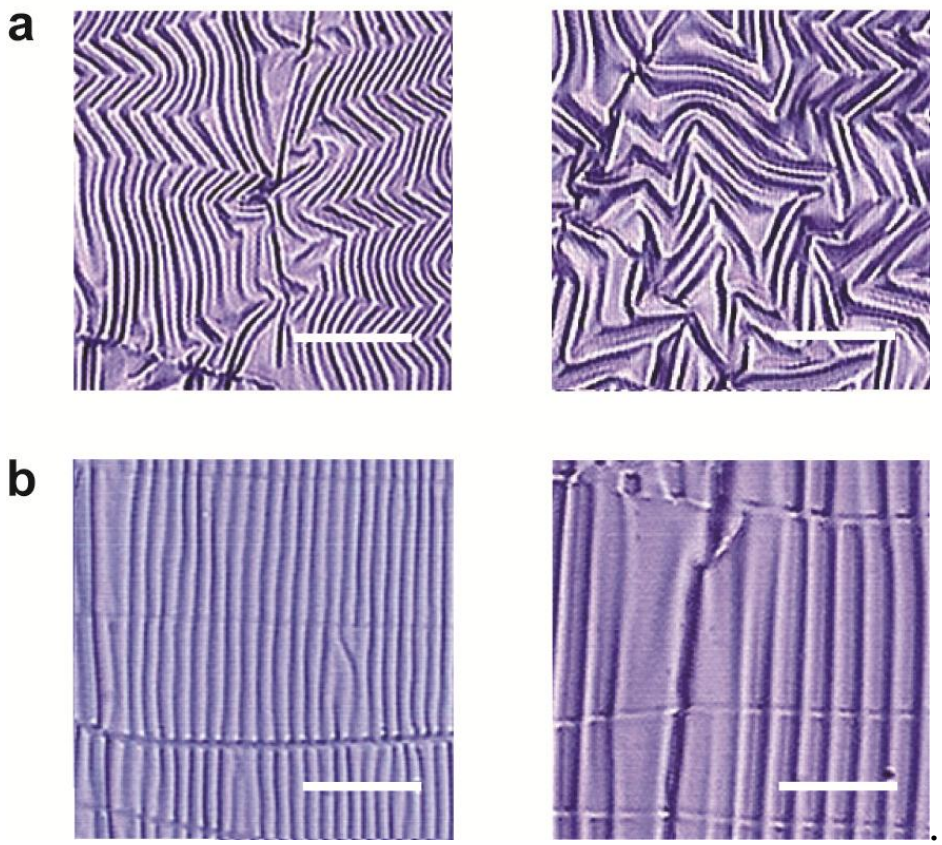

Figure S5. Optical images for wrinkle patterns with bending strains. **a.** Convex bending strain. **b.** Concave bending strain. Left images of **a, b**: bending angle 45°. Right image of **a, b**: bending angle: 60°. Flame exposure time: 30 s. All scale bars: 20 μm.

The largest difference can be seen in the surface structures and wavelengths. The samples exposed to the flame with a concave configuration formed randomized lines on the surface similar to multiple direction stretches. The samples exposed to heat with a convex configuration form straight lines similar to a uniaxial stretch. The wavelength differs for the degree that the sample is bent.