figure. In FIG. 9, the fins are 1.5 μm wide, 20 μm high, at 10 μm pitch. In FIG. 10, the square pillars are 2 μm per side and 20 μm high, with the same pitch. In all cases, the emitter arrays are squares, 0.21 mm per side. The data was obtained in pulse mode with a 0.2 ms pulse width.

[0051] The emission measurements and the corresponding Fowler-Nordheim plots are shown in FIGS. **11**-**13**. Each structure was tested repeatedly at a minimum of ten sweeps, in conditions ranging from where the electric field was ramped in a low duty cycle short duration pulse (0.2 msec at 1 Hz) to a continuous dc ramp over ten minutes. In these and all other tested devices, the emission characteristics did not vary or deteriorate as long as the emission was kept below a critical value dependent on the specific geometry of the structure, further described below. In FIG. **11**, the baseline emission of the 2D mesa structure is shown. FIGS. **12** and **13** demonstrate increased emission through spatial arrangement of the emitter arrays, with increasing **13** through reduced dimensionality, and the extracted values for β are shown in Table 1. The emitter array in FIG. **13** yielded stable emission in excess of 6 A/cm^2 at an applied macroscopic electric field of 7.5 V/μm. This value is comparable to emission values typically achieved using thermal sources, which are capable of emission in the range of 1 A/cm^2 to 10 A/cm^2.

[0052] In all of the structures tested, there is a critical emission current density above which the emission fluctuates and in no longer stable. Typically the onset of instability occurs at half the maximum values where catastrophic failure occurs and the structure no longer has significant emission. This is shown in FIG. **14**, where the pillar structure in FIG. **10** was tested to failure. Here, the emission instability above 6 A/cm^2 is apparent, and at a current density of 11 A/cm^2 at 9.0 V/μm, the device failed catastrophically. For emitters tested to failure, post-examinations through electron microscopy show melting of the structure at the emission points, and indicate local heating exceeded the thermal limits of the material.

[0053] FIG. **15** is a planar view of a SEM image of an electrochemically etched Si-face of a silicon carbide substrate formed using the Condition **2** conditions. FIG. **16** is a graph of current density versus electric field for the emitter shown in FIG. **15**.

[0054] In addition to high emission, reliability is critical and significantly influenced the approach taken in this effort. As the structures are monolithic, there are no interfaces that may be potential failure points. In addition, the porous morphology leads to a continuous supply of emission points as the surface wears.

[0055] In summary, a new form of field emitter is provided which demonstrates emission at levels comparable to thermal sources, comprised of monolithic nanostructured silicon carbide. Emission properties are tuned through control of field enhancement at a two-level hierarchy set by the local and global scale. It is believed that performance may be further enhanced through optimization of electrochemistry conditions and geometric design, and lead to high emission consistent with a specified operating field, and remain below the material's inherent limitations. The ease of fabrication and the performance demonstrated herein provides indications of wide use in a variety of applications.

[0056] Many other benefits will no doubt become apparent from future application and development of this technology.

[0057] All patents, applications, and articles noted herein are hereby incorporated by reference in their entirety.

[0058] As described hereinabove, the present subject matter overcomes many problems associated with previous strategies, systems and/or devices. However, it will be appreciated that various changes in the details, materials and arrangements of components, which have been herein described and illustrated in order to explain the nature of the present subject matter, may be made by those skilled in the art without departing from the principle and scope of the claimed subject matter, as expressed in the appended claims.

What is claimed is:

1. A method of forming a monolithic, homogeneous, and porous silicon carbide field emitter having a plurality of discrete emission projections extending from a face of the field emitter, the method comprising:

providing a silicon carbide substrate;

providing an anodizing solution including (i) at least one reducing agent, (ii) at least one oxidizer, and (iii) water;

electrochemically etching either face of the silicon carbide substrate with the anodizing solution for an effective period of time to thereby form a porous silicon carbide substrate;

subjecting the face of the porous silicon carbide substrate to ion etching to thereby form a silicon carbide field emitter having a plurality of discrete emission projections of porous silicon carbide extending from the face of the field emitter.

2. The method of claim **1** wherein the electrochemically etching uses a voltage within a range of from about 10V to about 100V.

3. The method of claim **2** wherein the electrochemically etching uses a voltage of about 20V.

4. The method of claim **1** wherein the period of time is at least 1 minute.

5. The method of claim **4** wherein the period of time is from about 5 minutes to about 4 hours.

6. The method of claim **1** wherein the reducing agent of the anodizing solution is hydrofluoric acid and the oxidizer of the anodizing solution is ethanol.

7. The method of claim **1** wherein the anodizing solution includes from about 1% to about 30% hydrofluoric acid and from about 5% to about 30% ethanol.

8. The method of claim **1** wherein ion etching is performed by focused ion beam (FIB) etching which may be gas-assisted, or reactive ion etching (RIE).

9. The method of claim **1** wherein the discrete emission projections have an average height within a range of from about 1 micron to about 100 microns, an average thickness of from about 0.1 microns to about 10 microns, and an average spacing of from about 1 micron to about 100 microns.

10. The method of claim **1** wherein the silicon carbide field emitter has an average pore wall thickness of from about 10 nm to about 1,000 nm, and an average pore size of from about 10 nm to about 1,000 nm.

11. The method of claim **1** wherein the electrochemically etching is performed at ambient temperature.

12. A porous silicon carbide field emitter having a plurality of discrete emission projections extending from an emission face of the field emitter, the field emitter being monolithic and homogenous in a direction transverse to the emission face of the field emitter.

13. The field emitter of claim **12** wherein the discrete emission projections have an average height within a range of from about 1 micron to about 100 microns, an average thick-