HW3_1

November 21, 2018

In [311]:
```
import numpy as np
import pandas as pd
f=open('Soft_Magnetic_Dataset.csv','r')
data=f.read()
f.close
```

Out[311]:
```
<function TextIOWrapper.close()>
```

In [312]:
```
def list_concat(word):
    out=''
    for i in word:
        out+=i
    return(out)
```

In [313]:
```
temp=[]
data1=[]
for t in data:
    if(t!='\n' and t!=','):
        temp.append(t)
    else:
        data1.append(temp)
        temp=[]
```

In [314]:
```
data2=[]
for i in data1:
    data2.append(list_concat(i))
```

In [315]:
```
cols=data2[0:42]
data3=data2[42:]
print(len(data3)/42)
```

```
1294.0
```

In [ ]:

In [316]:
```
data4=np.array(data3)
data5=np.reshape(data4,(1294,42))
m,n=data5.shape
import pdb
#pdb.set_trace()
```

In [317]:
```
data_df=pd.DataFrame(data=data5,columns=cols)
data_df.head()
data_df.iloc[0,-5]==''
data_df.head()
print(data_df.columns)
```

```
Index(['Fe', 'Si', 'C', 'Al', 'B', 'P', 'Ga', 'Ge', 'Cu', 'Ag', 'Au', 'Zn',
       'Ti', 'V', 'Cr', 'Zr', 'Nb', 'Mo', 'Hf', 'Ta', 'W', 'Ce', 'Pr', 'Gd',
       'U', 'Annealing temperature (K)', 'Annealing Time (s)',
       'Primary Crystallization Onset (K)',
       'Primary Crystallization Peak (K) ',
       'Secondary Crystallization Peak (K)', ' Longitudinal Annealing field',
       ' Transverse Annealing field', 'Ribbon Thickness (um) ',
       'Coercivity (A/m)', 'Curie Temperature (K)',
       'Core Loss (kW/m^3 @ 0.2T 100kHz)',
       'Electrical Resistivity (10^-6*ohm*m)', 'Permeability @ 1kHz',
       'Magnetostriction (10^-6)', 'Magnetic Saturation (T)',
       'Grain Diameter (nm)', 'Reference DOI'],
      dtype='object')
```

In [318]:
```
#preprocessing

#remove columns with zero elements

nonzero_ratio=np.zeros(len(cols))
counter=0
for col_i in cols:
    n_zeros=0
    #print('column : ',col_i)
    #import pdb; pdb.set_trace()
    for j in range(0,len(data_df[col_i])):
        if(data_df[col_i][j]=='0' or data_df[col_i][j]==''):
            n_zeros+=1
    nonzero_ratio[counter]=1-n_zeros/len(data_df[col_i])
    counter+=1
print('non zero ratio : ',nonzero_ratio)


drop_cols=[]
for i in range(0,len(data_df.columns)-1):
    if (nonzero_ratio[i]<.05):
        #print('non zero ratio',nonzero_ratio[i])
        drop_cols.append(cols[i])
#add the last column
drop_cols.append(cols[-1])
data_df_cleancols=data_df.drop(drop_cols,axis=1)
new_cols=data_df_cleancols.columns
```

```
        print(len(new_cols),len(cols))
        #import pdb; pdb.set_trace()
        data_df_cleancols.head()
        print(data_df_cleancols.columns)
```

```
non zero ratio :  [1.00000000e+00 7.34157651e-01 3.94126739e-02 9.65996909e-02
 9.76043277e-01 1.69242658e-01 2.08655332e-02 7.34157651e-02
 7.18701700e-01 1.23647604e-02 2.55023184e-02 7.72797527e-04
 6.95517774e-03 1.93199382e-02 2.39567233e-02 1.01236476e-01
 5.83462133e-01 8.50077280e-02 7.72797527e-03 3.55486862e-02
 5.79598145e-02 2.31839258e-03 7.72797527e-04 1.54559505e-03
 6.18238022e-03 1.00000000e+00 1.00000000e+00 8.88717156e-02
 4.08809892e-01 3.50850077e-01 5.40958269e-03 7.72797527e-03
 7.94435858e-01 5.72642968e-01 7.26429675e-02 2.93663060e-02
 3.70942813e-02 2.86707883e-01 1.56105100e-01 2.27202473e-01
 1.57650696e-01 1.00000000e+00]
23 42
Index(['Fe', 'Si', 'Al', 'B', 'P', 'Ge', 'Cu', 'Zr', 'Nb', 'Mo', 'W',
       'Annealing temperature (K)', 'Annealing Time (s)',
       'Primary Crystallization Onset (K)',
       'Primary Crystallization Peak (K) ',
       'Secondary Crystallization Peak (K)', 'Ribbon Thickness (um) ',
       'Coercivity (A/m)', 'Curie Temperature (K)', 'Permeability @ 1kHz',
       'Magnetostriction (10^-6)', 'Magnetic Saturation (T)',
       'Grain Diameter (nm)'],
      dtype='object')
```

In [319]:
```
drop_rows=[]
coer=data_df_cleancols['Coercivity (A/m)']
for i in range(0, len(coer)):
    if coer[i]=='':
        drop_rows.append(i)
print('Rows to be dropped',len(drop_rows))
data_df_cleanrows=data_df_cleancols.drop(drop_rows)
print('Remaining Rows',len(data_df_cleanrows))
data_df_cleanrows=data_df_cleanrows.reset_index(drop=True)
data_df_cleanrows.head()
```

```
Rows to be dropped 553
Remaining Rows 741
```

Out[319]:

	Fe	Si	Al	B	P	Ge	Cu	Zr	Nb	Mo	...	\
0	72.5	13.5	0	9	0	1	1	0	3	0	...	
1	71.5	9.5	1	9	0	5	1	0	3	0	...	
2	73.5	13.5	0	9	0	0	1	0	3	0	...	
3	73.5	13.5	0	9	0	0	1	0	3	0	...	
4	73.5	13.5	0	7	0	2	1	0	3	0	...	

```
  Primary Crystallization Onset (K) Primary Crystallization Peak (K)   \
0
1
2
3
4

  Secondary Crystallization Peak (K) Ribbon Thickness (um)  Coercivity (A/m)  \
0                                                       25      4644.936707
1                                                       25      4106.876281
2                                                       25      3922.927079
3                                                       25      2428.806915
4                                                       25      996.4925244

  Curie Temperature (K) Permeability @ 1kHz Magnetostriction (10^-6)  \
0
1
2
3
4

  Magnetic Saturation (T) Grain Diameter (nm)
0
1
2
3
4

[5 rows x 23 columns]
```

In [320]:
```
np.random.seed(0)
for col in new_cols:
    if col != 'Coercivity (A/m)':
        for i in range(0,len(data_df_cleanrows)):
            try:
                data_df_cleanrows[col][i]=float(data_df_cleanrows[col][i])+np.random.n
            except ValueError:
                    pass
data_df_cleanrows.head()
print(data_df_cleanrows.columns)
```

```
Index(['Fe', 'Si', 'Al', 'B', 'P', 'Ge', 'Cu', 'Zr', 'Nb', 'Mo', 'W',
       'Annealing temperature (K)', 'Annealing Time (s)',
       'Primary Crystallization Onset (K)',
       'Primary Crystallization Peak (K) ',
       'Secondary Crystallization Peak (K)', 'Ribbon Thickness (um) ',
       'Coercivity (A/m)', 'Curie Temperature (K)', 'Permeability @ 1kHz',
```

```
       'Magnetostriction (10^-6)', 'Magnetic Saturation (T)',
       'Grain Diameter (nm)'],
      dtype='object')
```

```
In [321]: m,n=data_df_cleanrows.shape
          for col in new_cols:
              if col!='Coercivity (A/m)':
                  for j in range(0,len(data_df_cleanrows)):
                      try:
                          data_df_cleanrows[col][j]=data_df_cleanrows[col][j][0]
                      except ValueError:
                          pass
                      except IndexError:
                          pass
                      except TypeError:
                          pass
```

```
In [322]: m,n=data_df_cleanrows.shape
          for i in range(m):
              for j in range(n):
                  if (data_df_cleanrows.iloc[i][j]==''):
                      data_df_cleanrows.iloc[i][j]=np.nan
```

```
In [323]: data_df_cleanrows.head()
```

Out[323]:

	Fe	Si	Al	B	P	Ge	Cu	\
0	76.0281	11.2196	-2.40747	8.15242	0.625268	1.37394	-1.11413	
1	72.3003	13.01	1.83409	7.80666	-0.386928	2.88894	-2.64939	
2	75.4575	13.234	1.37576	10.1341	2.4826	1.19122	1.48348	
3	77.9818	11.9686	0.0997145	10.9765	-0.311796	-2.7506	0.709696	
4	77.2351	14.6116	2.69607	5.97219	-1.47834	3.24602	2.00399	

	Zr	Nb	Mo	...	\
0	-2.08559	5.99051	1.37661	...	
1	-1.31121	2.4048	1.32479	...	
2	0.514308	1.50777	1.77779	...	
3	-0.713619	3.64489	1.08875	...	
4	-4.50449	0.183463	-1.45304	...	

	Primary Crystallization Onset (K)	Primary Crystallization Peak (K)	\
0	NaN	NaN	
1	NaN	NaN	
2	NaN	NaN	
3	NaN	NaN	
4	NaN	NaN	

	Secondary Crystallization Peak (K)	Ribbon Thickness (um)	Coercivity (A/m)	\
0	NaN	22.8576	4644.936707	

```
1                                NaN               26.1108      4106.876281
2                                NaN               21.5819      3922.927079
3                                NaN               23.6256      2428.806915
4                                NaN               25.1247       996.4925244

  Curie Temperature (K) Permeability @ 1kHz Magnetostriction (10^-6)  \
0                   NaN                  NaN                        NaN
1                   NaN                  NaN                        NaN
2                   NaN                  NaN                        NaN
3                   NaN                  NaN                        NaN
4                   NaN                  NaN                        NaN

  Magnetic Saturation (T) Grain Diameter (nm)
0                     NaN                 NaN
1                     NaN                 NaN
2                     NaN                 NaN
3                     NaN                 NaN
4                     NaN                 NaN

[5 rows x 23 columns]
```

In [324]:
```
from sklearn.preprocessing import StandardScaler
scaler=StandardScaler()
for col in new_cols:
    if col != 'Coercivity (A/m)':
        null_values=data_df_cleanrows[col].isnull()
        data_df_cleanrows.loc[~null_values,[col]]=scaler.fit_transform(data_df_cleanro
```

In [325]:
```
data_df_cleanrows.head()
```

Out[325]:
```
          Fe        Si         Al          B         P        Ge         Cu  \
0  -0.215755  0.624717   -1.17265 -0.0661397 -0.272111  0.222183  -0.913517
1  -0.818957  0.909259   0.680074  -0.173938 -0.550679   0.72874   -1.65492
2   -0.30809  0.944867   0.479876   0.551689   0.23905  0.161089   0.340914
3   0.100374  0.743754 -0.0775066   0.814312 -0.530002  -1.15691 -0.0327589
4 -0.0204459    1.1638    1.05659  -0.745866 -0.851049  0.848136   0.592277

         Zr        Nb        Mo         ...          \
0 -0.984052   1.66608  0.534391         ...
1 -0.677158  0.320822  0.509423         ...
2  0.046319 -0.015721  0.727698         ...
3 -0.440323  0.786069  0.395685         ...
4  -1.94269 -0.512567  -0.82906         ...

  Primary Crystallization Onset (K) Primary Crystallization Peak (K)   \
0                               NaN                               NaN
1                               NaN                               NaN
2                               NaN                               NaN
```

```
3                                NaN                                NaN
4                                NaN                                NaN

  Secondary Crystallization Peak (K) Ribbon Thickness (um)  Coercivity (A/m)  \
0                                NaN              0.0261461      4644.936707
1                                NaN               0.576264      4106.876281
2                                NaN              -0.189586      3922.927079
3                                NaN               0.156016      2428.806915
4                                NaN               0.409522      996.4925244

  Curie Temperature (K) Permeability @ 1kHz Magnetostriction (10^-6)  \
0                   NaN                 NaN                        NaN
1                   NaN                 NaN                        NaN
2                   NaN                 NaN                        NaN
3                   NaN                 NaN                        NaN
4                   NaN                 NaN                        NaN

  Magnetic Saturation (T) Grain Diameter (nm)
0                     NaN                 NaN
1                     NaN                 NaN
2                     NaN                 NaN
3                     NaN                 NaN
4                     NaN                 NaN

[5 rows x 23 columns]
```

In [334]:
```
"""Obtain the features to apply PCA on"""

new_cols1=[]
cols=[]
for col in new_cols:
    cols.append(col)
#print(type(cols),cols)
new_cols1=cols[0:12]
print(new_cols1,len(new_cols1))
```

```
['Fe', 'Si', 'Al', 'B', 'P', 'Ge', 'Cu', 'Zr', 'Nb', 'Mo', 'W', 'Annealing temperature (K)'] 12
```

In [336]:
```
from sklearn.decomposition import PCA
pca = PCA(n_components=12)
print(data_df_cleanrows[new_cols1].isnull().sum().sum())
data=data_df_cleanrows[new_cols1]
X=data[data.notna()]
pca.fit(X)
print(X.isnull().sum().sum())
```

```
0
0
```

```
In [333]: #find number of NAN values
          for i in range(0,12):
              null_values=data_df_cleanrows[new_cols[i]].isnull()
              type(null_values)
              print(len(data_df_cleanrows.loc[~null_values,[new_cols[i]]]))
          print(new_cols[0:12])
```

```
741
741
741
741
741
741
741
741
741
741
741
741
Index(['Fe', 'Si', 'Al', 'B', 'P', 'Ge', 'Cu', 'Zr', 'Nb', 'Mo', 'W',
       'Annealing temperature (K)'],
      dtype='object')
```

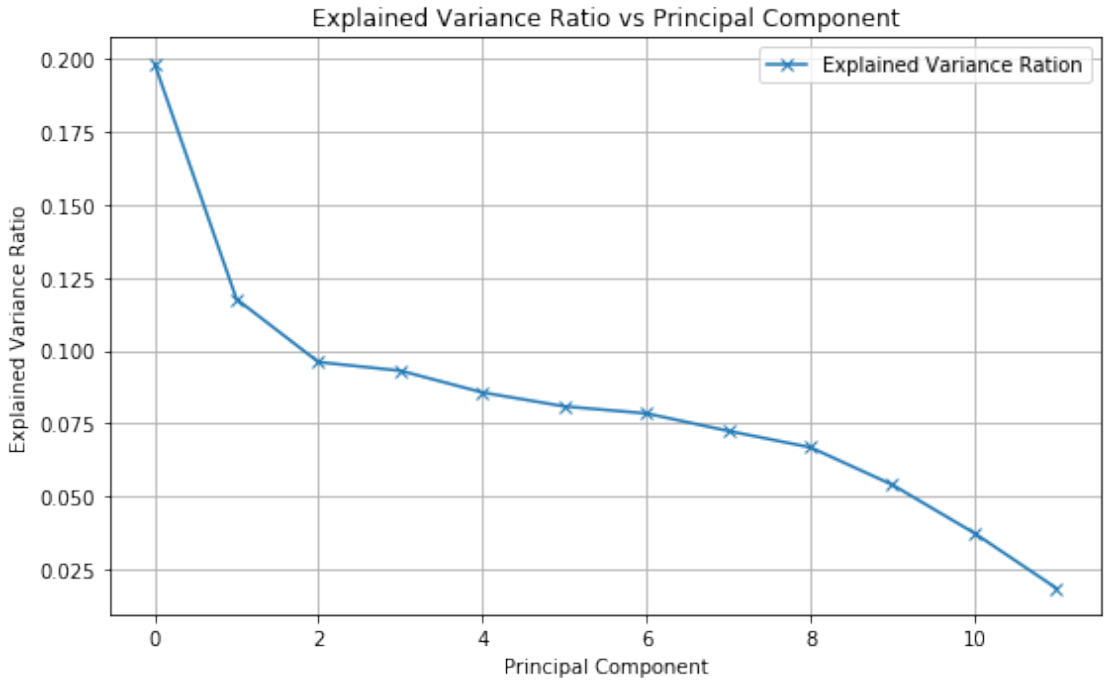
```
In [367]:
```

```
Out[367]: 0.07339656151675539
```

```
In [343]: #plot error vs n
          import matplotlib.pyplot as plt
          fig, ax = plt.subplots(figsize=[8,5])
          plt.plot(pca.explained_variance_ratio_,marker='x',label='Explained Variance Ration')
          plt.hold(True)
          plt.title('Explained Variance Ratio vs Principal Component')
          plt.ylabel('Explained Variance Ratio')
          plt.xlabel('Principal Component')
          fig.tight_layout()
          ax.legend()
          plt.grid(True)
          plt.show
          fig.savefig('hw3_3a.png')
```

```
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:5: MatplotlibDeprecationWarning
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
  """
C:\Users\aksha\Anaconda3\lib\site-packages\matplotlib\__init__.py:911: MatplotlibDeprecationWarn
  mplDeprecation)
```

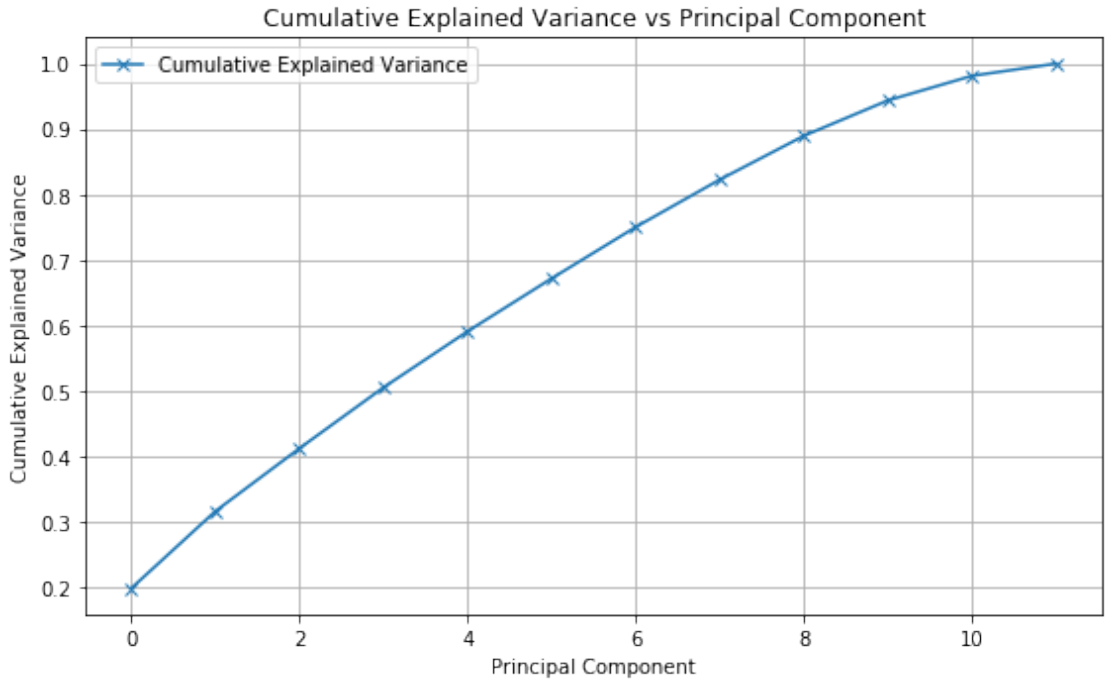
```
C:\Users\aksha\Anaconda3\lib\site-packages\matplotlib\rcsetup.py:156: MatplotlibDeprecationWarni
  mplDeprecation)
```



In [345]:
```
cum_ratio=[]
cum=0
for ratio in pca.explained_variance_ratio_:
    cum+=ratio
    cum_ratio.append(cum)
#plot error vs n
fig, ax = plt.subplots(figsize=[8,5])
plt.plot(cum_ratio,marker='x',label='Cumulative Explained Variance')
plt.hold(True)
plt.title('Cumulative Explained Variance vs Principal Component')
plt.ylabel('Cumulative Explained Variance')
plt.xlabel('Principal Component')
fig.tight_layout()
ax.legend()
plt.grid(True)
plt.show
fig.savefig('hw3_3b.png')
```

```
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:10: MatplotlibDeprecationWarnin
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
```

```
    Axes and/or Figure.
  # Remove the CWD from sys.path while we load stuff.
C:\Users\aksha\Anaconda3\lib\site-packages\matplotlib\__init__.py:911: MatplotlibDeprecationWarn
  mplDeprecation)
C:\Users\aksha\Anaconda3\lib\site-packages\matplotlib\rcsetup.py:156: MatplotlibDeprecationWarni
  mplDeprecation)
```

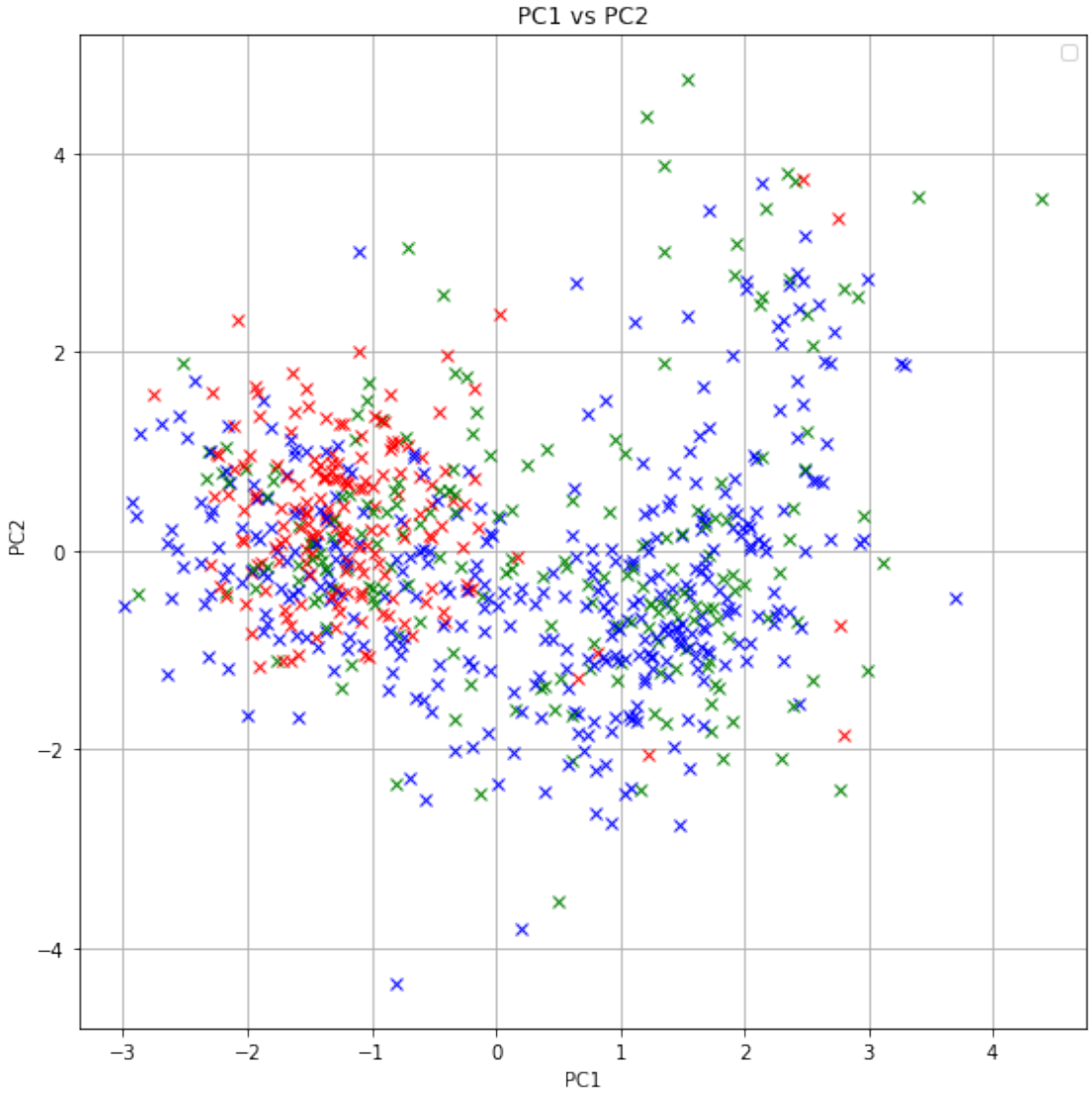


In [355]:
```
for i in range(0,len(data_df_cleanrows[new_cols[-6]])):
    if float(data_df_cleanrows[new_cols[-6]][i])<=2:
        data_df_cleanrows[new_cols[-6]][i]=0
    elif float(data_df_cleanrows[new_cols[-6]][i])<=8 and float(data_df_cleanrows[new_
        data_df_cleanrows[new_cols[-6]][i]=1
    else:
        data_df_cleanrows[new_cols[-6]][i]=2
```

In [378]:
```
#plot PC against each other with Coercivity ranges
#PC1, PC2 and PC3
PC1=np.array(pca.components_[0])
PC2=np.array(pca.components_[1])
PC3=np.array(pca.components_[2])
b=np.array(X.iloc[740])
np.dot(a,b)
```

```
fig, ax = plt.subplots(figsize=[8,8])
#first PC1 and PC2
for i in range(0,len(data_df_cleanrows[new_cols[-6]])):
    pt=np.array(X.iloc[i])
    x=np.dot(pt,PC1)
    y=np.dot(pt,PC2)
    if data_df_cleanrows[new_cols[-6]][i]==0:
        plt.plot(x,y,'r',marker='x')
        plt.hold(True)
    elif data_df_cleanrows[new_cols[-6]][i]==1:
        plt.plot(x,y,'g',marker='x')
        plt.hold(True)
    else:
        plt.plot(x,y,'b',marker='x')
        plt.hold(True)

plt.title('PC1 vs PC2')
plt.ylabel('PC2')
plt.xlabel('PC1')
fig.tight_layout()
ax.legend()
plt.grid(True)
plt.show
fig.savefig('hw3_4a.png')
```

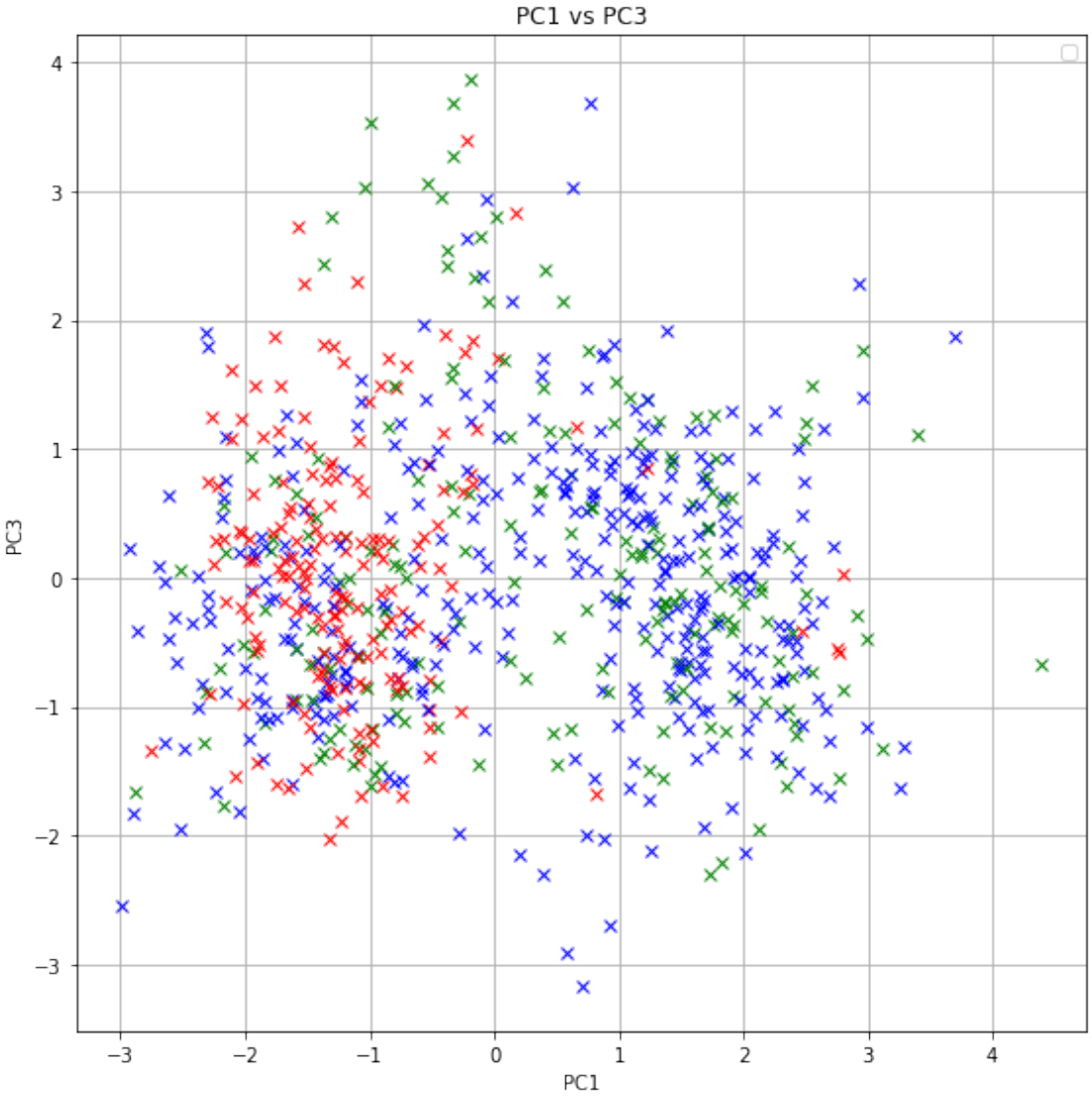
```
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:23: MatplotlibDeprecationWarnin
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
C:\Users\aksha\Anaconda3\lib\site-packages\matplotlib\__init__.py:911: MatplotlibDeprecationWarn
  mplDeprecation)
C:\Users\aksha\Anaconda3\lib\site-packages\matplotlib\rcsetup.py:156: MatplotlibDeprecationWarni
  mplDeprecation)
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:20: MatplotlibDeprecationWarnin
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:17: MatplotlibDeprecationWarnin
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
No handles with labels found to put in legend.
```




```
In [375]: fig, ax = plt.subplots(figsize=[8,8])
          #next PC1 and PC3
          for i in range(0,len(data_df_cleanrows[new_cols[-6]])):
              pt=np.array(X.iloc[i])
              x=np.dot(pt,PC1)
              y=np.dot(pt,PC3)
              if data_df_cleanrows[new_cols[-6]][i]==0:
                  plt.plot(x,y,'r',marker='x')
                  plt.hold(True)
              elif data_df_cleanrows[new_cols[-6]][i]==1:
                  plt.plot(x,y,'g',marker='x')
                  plt.hold(True)
              else:
```

```
                plt.plot(x,y,'b',marker='x')
                plt.hold(True)

        plt.title('PC1 vs PC3')
        plt.ylabel('PC3')
        plt.xlabel('PC1')
        fig.tight_layout()
        ax.legend()
        plt.grid(True)
        plt.show
        fig.savefig('hw3_4b.png')
```

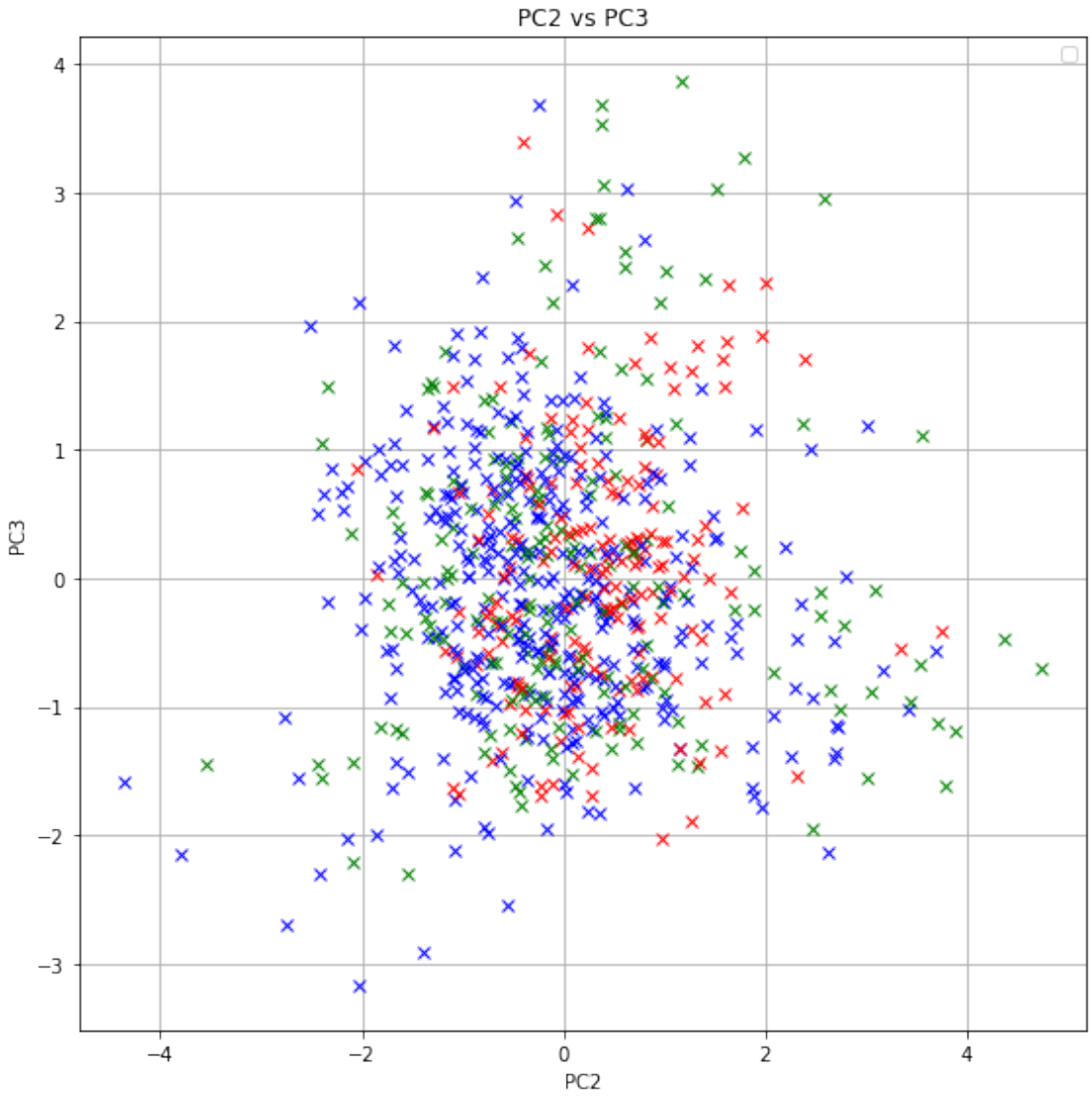
```
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:15: MatplotlibDeprecationWarnin
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
  from ipykernel import kernelapp as app
C:\Users\aksha\Anaconda3\lib\site-packages\matplotlib\__init__.py:911: MatplotlibDeprecationWarn
  mplDeprecation)
C:\Users\aksha\Anaconda3\lib\site-packages\matplotlib\rcsetup.py:156: MatplotlibDeprecationWarni
  mplDeprecation)
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:12: MatplotlibDeprecationWarnin
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
  if sys.path[0] == '':
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:9: MatplotlibDeprecationWarning
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
  if __name__ == '__main__':
No handles with labels found to put in legend.
```




```
In [381]: fig, ax = plt.subplots(figsize=[8,8])
          #finally PC2 and PC23
          for i in range(0,len(data_df_cleanrows[new_cols[-6]])):
              pt=np.array(X.iloc[i])
              x=np.dot(pt,PC2)
              y=np.dot(pt,PC3)
              if data_df_cleanrows[new_cols[-6]][i]==0:
                  plt.plot(x,y,'r',marker='x')
                  plt.hold(True)
              elif data_df_cleanrows[new_cols[-6]][i]==1:
                  plt.plot(x,y,'g',marker='x')
                  plt.hold(True)
              else:
```

```
                plt.plot(x,y,'b',marker='x')
                plt.hold(True)

        plt.title('PC2 vs PC3')
        plt.ylabel('PC3')
        plt.xlabel('PC2')
        fig.tight_layout()
        ax.legend()
        plt.grid(True)
        plt.show
        fig.savefig('hw3_4c.png')
```

```
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:15: MatplotlibDeprecationWarnin
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
  from ipykernel import kernelapp as app
C:\Users\aksha\Anaconda3\lib\site-packages\matplotlib\__init__.py:911: MatplotlibDeprecationWarn
  mplDeprecation)
C:\Users\aksha\Anaconda3\lib\site-packages\matplotlib\rcsetup.py:156: MatplotlibDeprecationWarni
  mplDeprecation)
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:12: MatplotlibDeprecationWarnin
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
  if sys.path[0] == '':
C:\Users\aksha\Anaconda3\lib\site-packages\ipykernel_launcher.py:9: MatplotlibDeprecationWarning
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
  if __name__ == '__main__':
No handles with labels found to put in legend.
```




```
In [380]: print(pca.get_covariance())
```

```
[[ 1.00135135 -0.66151098 -0.14876181 -0.02993597  0.18721299 -0.14678145
  -0.03768452  0.18188581 -0.31582802 -0.09259027  0.06143245 -0.28264495]
 [-0.66151098  1.00135135  0.00627696  0.06568258 -0.4016836  -0.08846236
   0.06163139 -0.16066039  0.18883969  0.12074562 -0.11500165  0.36640789]
 [-0.14876181  0.00627696  1.00135135 -0.08189913  0.15249299 -0.0154062
  -0.00307291 -0.02590294  0.01138607 -0.05249769 -0.06988509  0.0164819 ]
 [-0.02993597  0.06568258 -0.08189913  1.00135135 -0.40090333 -0.02723041
   0.04944866 -0.10655042  0.06350481  0.0483009   0.01772845  0.01906001]
 [ 0.18721299 -0.4016836   0.15249299 -0.40090333  1.00135135 -0.055116
  -0.03769337 -0.09254025 -0.1546759  -0.05103195 -0.06564444 -0.32328742]
 [-0.14678145 -0.08846236 -0.0154062  -0.02723041 -0.055116    1.00135135
```

```
  0.03965982 -0.01132244  0.11318762 -0.00814852 -0.07006339 -0.05778079]
 [-0.03768452  0.06163139 -0.00307291  0.04944866 -0.03769337  0.03965982
   1.00135135  0.00407828  0.00415234 -0.00591753 -0.04126098  0.01776972]
 [ 0.18188581 -0.16066039 -0.02590294 -0.10655042 -0.09254025 -0.01132244
   0.00407828  1.00135135 -0.06498361 -0.07867549  0.00425655  0.01936066]
 [-0.31582802  0.18883969  0.01138607  0.06350481 -0.1546759   0.11318762
   0.00415234 -0.06498361  1.00135135  0.02141887 -0.05351544  0.1946975 ]
 [-0.09259027  0.12074562 -0.05249769  0.0483009  -0.05103195 -0.00814852
  -0.00591753 -0.07867549  0.02141887  1.00135135  0.02497942  0.05115617]
 [ 0.06143245 -0.11500165 -0.06988509  0.01772845 -0.06564444 -0.07006339
  -0.04126098  0.00425655 -0.05351544  0.02497942  1.00135135  0.09330368]
 [-0.28264495  0.36640789  0.0164819   0.01906001 -0.32328742 -0.05778079
   0.01776972  0.01936066  0.1946975   0.05115617  0.09330368  1.00135135]]
```

In [387]:
```
"""The loading matrix W, we have the PCs in the columns and the original variables in
comp_mat=pca.components_

df_components=pd.DataFrame(np.transpose(comp_mat),columns=['PC1','PC2','PC3','PC4','PC
df_components
```

Out[387]:

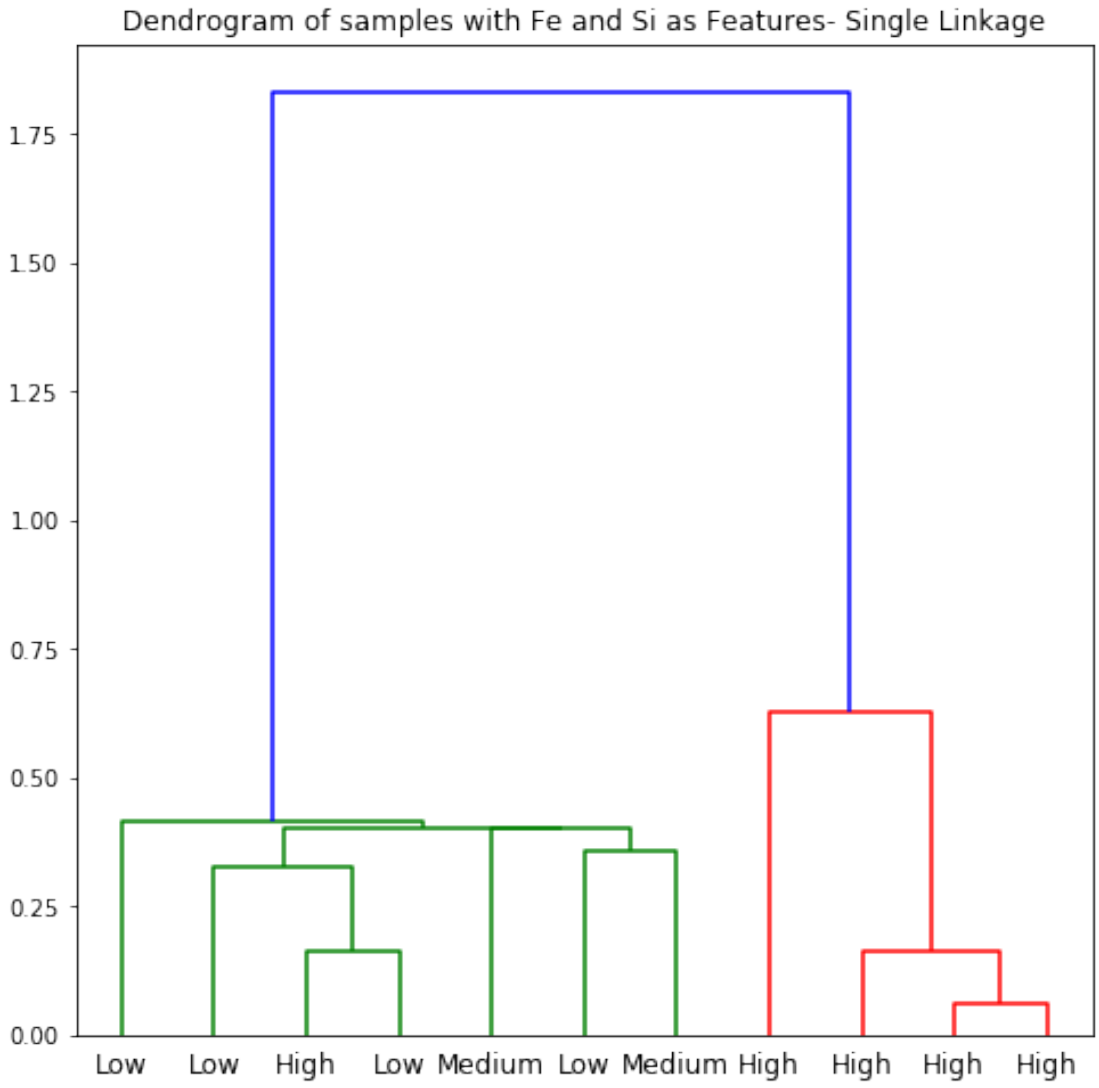
	PC1	PC2	PC3	PC4	PC5	PC6	PC7	\
0	0.495333	-0.332875	0.010266	0.009189	-0.055634	-0.016890	-0.052244	
1	-0.533270	0.111963	-0.156031	-0.050673	-0.174002	0.076273	-0.155193	
2	-0.006857	0.461403	-0.177270	0.096178	-0.248446	-0.319845	0.234003	
3	-0.185512	-0.468177	0.333770	-0.275425	-0.210867	-0.407294	0.046601	
4	0.396329	0.477389	-0.109116	-0.157813	0.045252	0.099786	0.081968	
5	-0.043539	0.158239	0.627001	0.211257	0.471186	0.127733	0.159545	
6	-0.061899	-0.012510	0.302562	0.089112	-0.575218	0.532712	0.498176	
7	0.131639	-0.231033	-0.099144	0.696356	-0.035059	0.220873	-0.294988	
8	-0.306006	0.141902	0.197357	0.171336	0.325309	-0.148213	0.065714	
9	-0.125895	-0.048304	-0.077698	-0.492704	0.220865	0.580332	-0.248261	
10	0.033875	-0.326175	-0.386266	-0.053671	0.383246	0.031405	0.688125	
11	-0.380837	-0.096149	-0.363489	0.273602	0.052764	0.084433	0.097049	

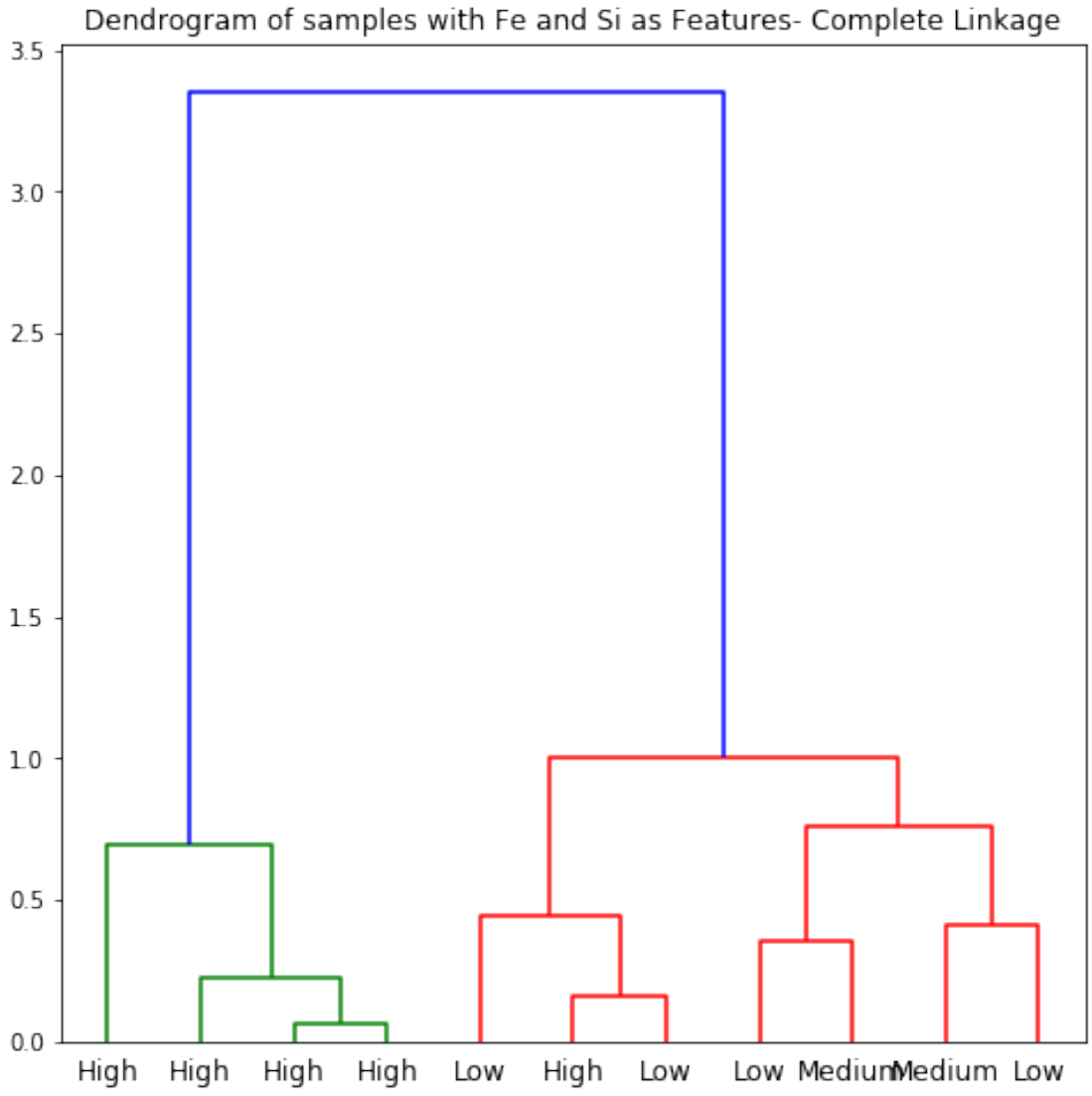
	PC8	PC9	PC10	PC11	PC12
0	0.020629	0.191008	-0.364859	-0.379433	0.568805
1	-0.162216	-0.237466	0.243980	-0.097995	0.681293
2	0.692446	0.008677	-0.053177	-0.201126	0.069030
3	0.280567	0.085261	0.012919	0.487182	0.152017
4	-0.135396	0.165318	0.003406	0.636431	0.329803
5	0.177553	-0.402384	-0.179897	0.027607	0.212028
6	-0.063445	0.167828	0.003922	-0.028689	-0.025683
7	0.315756	0.062744	0.345906	0.260491	0.079861
8	-0.093367	0.796974	0.120510	-0.129115	0.103576
9	0.498848	0.185489	-0.038191	-0.028542	-0.017158
10	0.058694	-0.083969	0.309676	-0.002294	0.112255
11	-0.021572	0.042550	-0.735144	0.276863	-0.006277

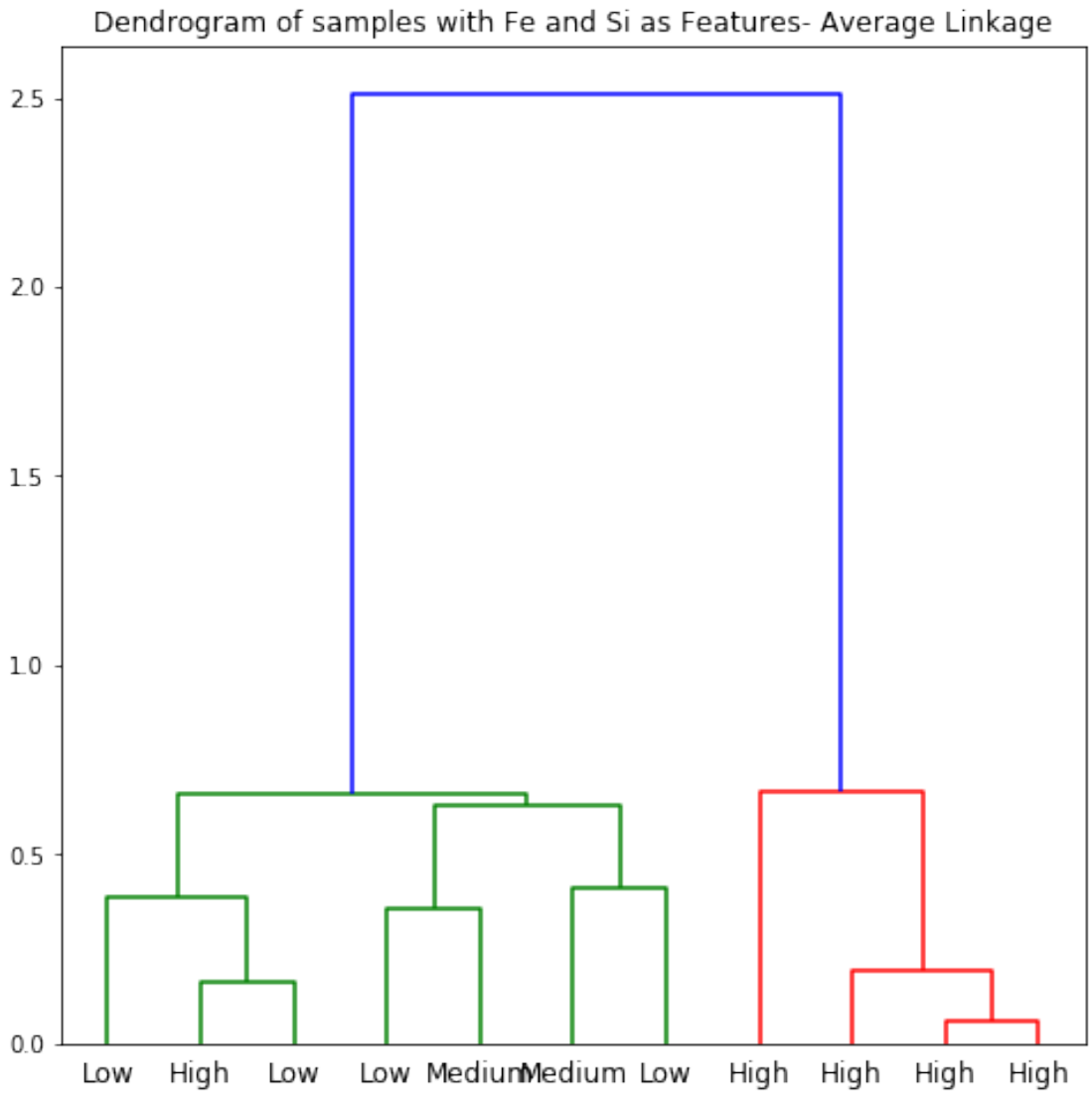
In [392]:
```
"""Most important feature"""
#if we look at PC1 then we can decide that feature 1 is the most important feature
new_cols1[0:2]
```

Out[392]:
```
['Fe', 'Si']
```

In [405]:
```
"""Hierarchical Clustering"""
from scipy.cluster.hierarchy import dendrogram, linkage
X1=data_df_cleanrows[new_cols1[0:2]]
m,n=X1.shape
X=[]
labels1=[]
for i in range (0,132,12):
    X.append(X1.iloc[i])
    if data_df_cleanrows['Coercivity (A/m)'][i]==0:
        labels1.append('Low')
    elif data_df_cleanrows['Coercivity (A/m)'][i]==1:
        labels1.append('Medium')
    else:
        labels1.append('High')

#single linkage
#import pdb;pdb.set_trace()
Z=linkage(X,'single')
fig, ax = plt.subplots(figsize=[8,8])
dendrogram(Z,labels=labels1)
plt.title('Dendrogram of samples with Fe and Si as Features- Single Linkage')
plt.show()
fig.savefig('hw3_6a.png')

#complete
Z=linkage(X,'complete')
fig, ax = plt.subplots(figsize=[8,8])
dendrogram(Z,labels=labels1)
plt.title('Dendrogram of samples with Fe and Si as Features- Complete Linkage')
plt.show()
fig.savefig('hw3_6b.png')

#average linkage
Z=linkage(X,'average')
fig, ax = plt.subplots(figsize=[8,8])
dendrogram(Z,labels=labels1)
plt.title('Dendrogram of samples with Fe and Si as Features- Average Linkage')
plt.show()
fig.savefig('hw3_6c.png')
```


Dendrogram of samples with Fe and Si as Features- Single Linkage
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Low
Low
High
Low
Medium
Low
Medium
High
High
High
High


Dendrogram of samples with Fe and Si as Features- Complete Linkage
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
High
High
High
High
Low
High
Low
Low
Medium
Medium
Low


Dendrogram of samples with Fe and Si as Features- Average Linkage
2.5
2.0
1.5
1.0
0.5
0.0
Low
High
Low
Low
Medium
Medium
Low
High
High
High
High