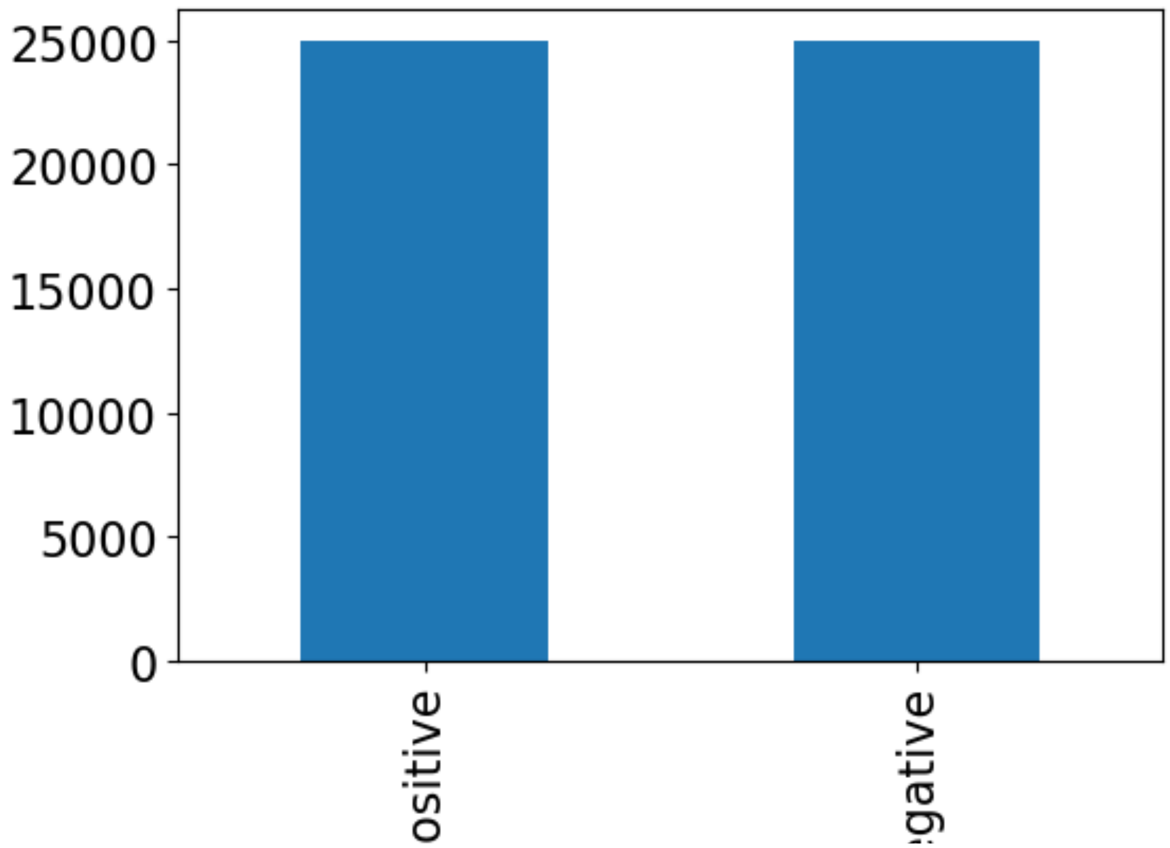
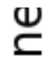
In [2]:
```
import os
import numpy as np
import pandas as pd
import random
import matplotlib.pyplot as plt
plt.rcParams.update({'font.size':16})


data = pd.read_csv('IMDB Dataset.csv')

# display the first 5 rows of data
print()
print(data.head(5))

print('\n')
plt.figure(figsize = (6,4))
data['sentiment'].value_counts().plot(kind = 'bar')
plt.show()
```

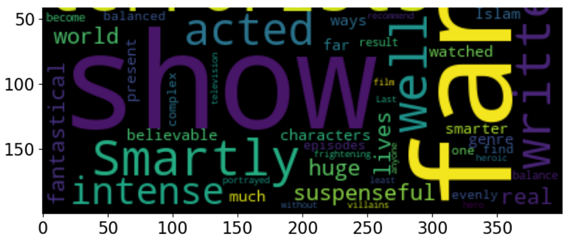
```
                                              review sentiment
0  One of the other reviewers has mentioned that ...  positive
1  A wonderful little production. <br /><br />The...  positive
2  I thought this was a wonderful way to spend ti...  positive
3  Basically there's a family where a little boy ...  negative
4  Petter Mattei's "Love in the Time of Money" is...  positive
```

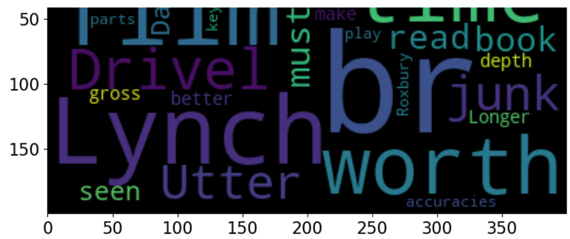




In [8]:
```
# Choose randomly a positive review and a negative review
ind_positive = random.choice(list(data[data['sentiment'] == 'positi
ind_negative = random.choice(list(data[data['sentiment'] == 'negati

review_positive = data['review'][ind_positive]
review_negative = data['review'][ind_negative]

print('Positive review: ', review_positive)
print('\n')
print('Negative review: ', review_negative)
print('\n')

from wordcloud import WordCloud
cloud_positive = WordCloud().generate(review_positive)
cloud_negative = WordCloud().generate(review_negative)

plt.figure(figsize = (20,15))
plt.subplot(1,2,1)
plt.imshow(cloud_positive)
plt.title('Positive review')

plt.subplot(1,2,2)
plt.imshow(cloud_negative)
plt.title('Negative review')
plt.show()
```

```
Positive review:  Smartly written, well acted, intense and suspens
eful. This show lives in the real world, not as fantastical as is
"24",(and I am a huge fan of 24,incidentally). It has believable c
haracters and in many ways is much smarter than most in this genre
. It tries to present both sides of Islam. So far, I have watched
the first 4 episodes and find the story to be more evenly balanced
. The terrorists are more complex and not one dimensional. And as
a result of that balance, the terrorists become more frightening t
han the typical villains being portrayed in film and on television
. Last but not least, the hero is truly heroic without being a car
toon. I recommend this show for anyone who is a fan of 24 and the
like.


Negative review:  Drivel. Utter junk. The writers must not have re
ad the book, or seen David Lynch's film. Not worth wasting your ti
me.<br /><br />Longer does not make better. While more in-depth th
en Lynch's film, it has gross in-accuracies, and down-play's key p
arts of the story.<br /><br />"A Night at the Roxbury" is more wor
th your time.
```





In [9]:
```
import re

def remove_url(text):
    url_tag = re.compile(r'https://\S+|www\.\S+')
    text = url_tag.sub(r'', text)
    return text

def remove_html(text):
    html_tag = re.compile(r'<.*?>')
    text = html_tag.sub(r'', text)
    return text

def remove_punctuation(text):
    punct_tag = re.compile(r'[^\w\s]')
    text = punct_tag.sub(r'', text)
    return text

def remove_special_character(text):
    special_tag = re.compile(r'[^a-zA-Z0-9\s]')
    text = special_tag.sub(r'', text)
    return text

def remove_emojis(text):
    emoji_pattern = re.compile("["
                               u"\U0001F600-\U0001F64F"  # emoticon
                               u"\U0001F300-\U0001F5FF"  # symbols
                               u"\U0001F680-\U0001F6FF"  # transpor
                               u"\U0001F1E0-\U0001F1FF"  # flags (i
                               "]+", flags=re.UNICODE)
    text = emoji_pattern.sub(r'', text)
    return text

def clean_text(text):
    text = remove_url(text)
    text = remove_html(text)
    text = remove_punctuation(text)
    text = remove_special_character(text)
    text = remove_emojis(text)
    text = text.lower()

    return text
```

In [10]:
```
data['processed'] = data['review'].apply(lambda x: clean_text(x))
data.head()
```

Out[10]:

	review	sentiment	processed
0	One of the other reviewers has mentioned that ...	positive	one of the other reviewers has mentioned that ...
1	A wonderful little production. The...	positive	a wonderful little production the filming tech...
2	I thought this was a wonderful way to spend ti...	positive	i thought this was a wonderful way to spend ti...
3	Basically there's a family where a little boy ...	negative	basically theres a family where a little boy j...
4	Petter Mattei's "Love in the Time of Money" is...	positive	petter matteis love in the time of money is a ...

In [11]:
```
bel'] = data['sentiment'].apply(lambda x: 0 if x == 'negative' else

 data[data['Label'] == 0]
 data[data['Label'] == 1]

ze = int(0.7*25000)
 = int(0.2*25000)

in = pd.concat((data_0[:train_size], data_1[:train_size]), axis = 0)
 = pd.concat((data_0[train_size: (train_size + val_size)], data_1[tr
t = pd.concat((data_0[(train_size + val_size):], data_1[(train_size

 y_train = list(data_train['processed']), np.array(data_train['Label
_val = list(data_val['processed']), np.array(data_val['Label'])
y_test = list(data_test['processed']), np.array(data_test['Label'])

rain size:', len(X_train))
alidation size: ', len(X_val))
est size: ', len(X_test))
```

```
Train size: 35000
Validation size:  10000
Test size:  5000
```

In [14]:
```
vocab_size = 10000
max_length = 500
trunc_type = 'post'
oov_tok = 'OOV'

from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences

# Tokenization
token = Tokenizer(num_words = vocab_size, oov_token = oov_tok)
token.fit_on_texts(X_train)
index_word = token.index_word

# Convert texts to sequences
train_seq = token.texts_to_sequences(X_train)
val_seq = token.texts_to_sequences(X_val)
test_seq = token.texts_to_sequences(X_test)

# Sequence padding
#Since the sequences have different lengtht, then we use padding me
#The parameter "maxlen" sets the maximum length of the output seque
#    + If length of the input sequence is larger than "maxlen", the
#    + If length of the input sequence is smaller than "maxlen", th

train_pad = pad_sequences(train_seq, maxlen = max_length, padding =
val_pad = pad_sequences(val_seq, maxlen = max_length, padding = 'po
test_pad = pad_sequences(test_seq, maxlen = max_length, padding = '
```

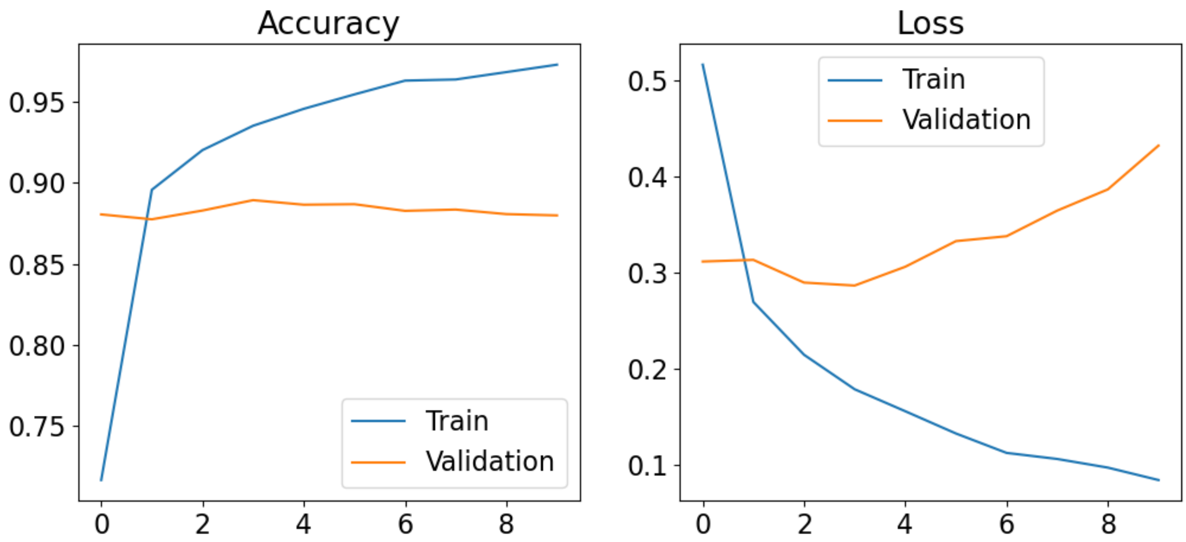
In [15]:
```
# Shuffle the training set
p = np.random.permutation(len(train_pad))
train_pad = train_pad[p]
y_train = y_train[p]
```

In [17]:

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Embedding, Conv1D, AveragePooli
from tensorflow.keras.utils import plot_model

embedding_dim = 64

model = Sequential()
model.add(Embedding(vocab_size, embedding_dim, input_length = max_l
model.add(Conv1D(filters = 32, kernel_size = 3, padding = 'same', a
model.add(AveragePooling1D(pool_size = 2))
model.add(Bidirectional(LSTM(200, dropout = 0.5)))
model.add(Dense(1, activation = 'sigmoid'))
model.compile(loss = 'binary_crossentropy', optimizer = 'adam', met

plot_model(model, show_shapes = True)

H = model.fit(train_pad, y_train, epochs = 10, batch_size = 128,
             validation_data = (val_pad, y_val) )
```

```
You must install pydot (`pip install pydot`) and install graphviz
(see instructions at https://graphviz.gitlab.io/download/)
(https://graphviz.gitlab.io/download/)) for plot_model to work.
Epoch 1/10
274/274 [==============================] - 960s 3s/step - loss: 0.
5168 - accuracy: 0.7168 - val_loss: 0.3118 - val_accuracy: 0.8805
Epoch 2/10
274/274 [==============================] - 968s 4s/step - loss: 0.
2697 - accuracy: 0.8957 - val_loss: 0.3135 - val_accuracy: 0.8775
Epoch 3/10
274/274 [==============================] - 982s 4s/step - loss: 0.
2147 - accuracy: 0.9201 - val_loss: 0.2899 - val_accuracy: 0.8829
Epoch 4/10
274/274 [==============================] - 984s 4s/step - loss: 0.
1788 - accuracy: 0.9351 - val_loss: 0.2868 - val_accuracy: 0.8893
Epoch 5/10
274/274 [==============================] - 985s 4s/step - loss: 0.
1559 - accuracy: 0.9456 - val_loss: 0.3064 - val_accuracy: 0.8865
Epoch 6/10
274/274 [==============================] - 989s 4s/step - loss: 0.
1328 - accuracy: 0.9545 - val_loss: 0.3330 - val_accuracy: 0.8868
Epoch 7/10
274/274 [==============================] - 988s 4s/step - loss: 0.
1126 - accuracy: 0.9629 - val_loss: 0.3382 - val_accuracy: 0.8827
Epoch 8/10
274/274 [==============================] - 972s 4s/step - loss: 0.
1062 - accuracy: 0.9637 - val_loss: 0.3648 - val_accuracy: 0.8835
Epoch 9/10
274/274 [==============================] - 967s 4s/step - loss: 0.
0972 - accuracy: 0.9682 - val_loss: 0.3869 - val_accuracy: 0.8807
Epoch 10/10
274/274 [==============================] - 966s 4s/step - loss: 0.
0843 - accuracy: 0.9728 - val_loss: 0.4325 - val_accuracy: 0.8799
```

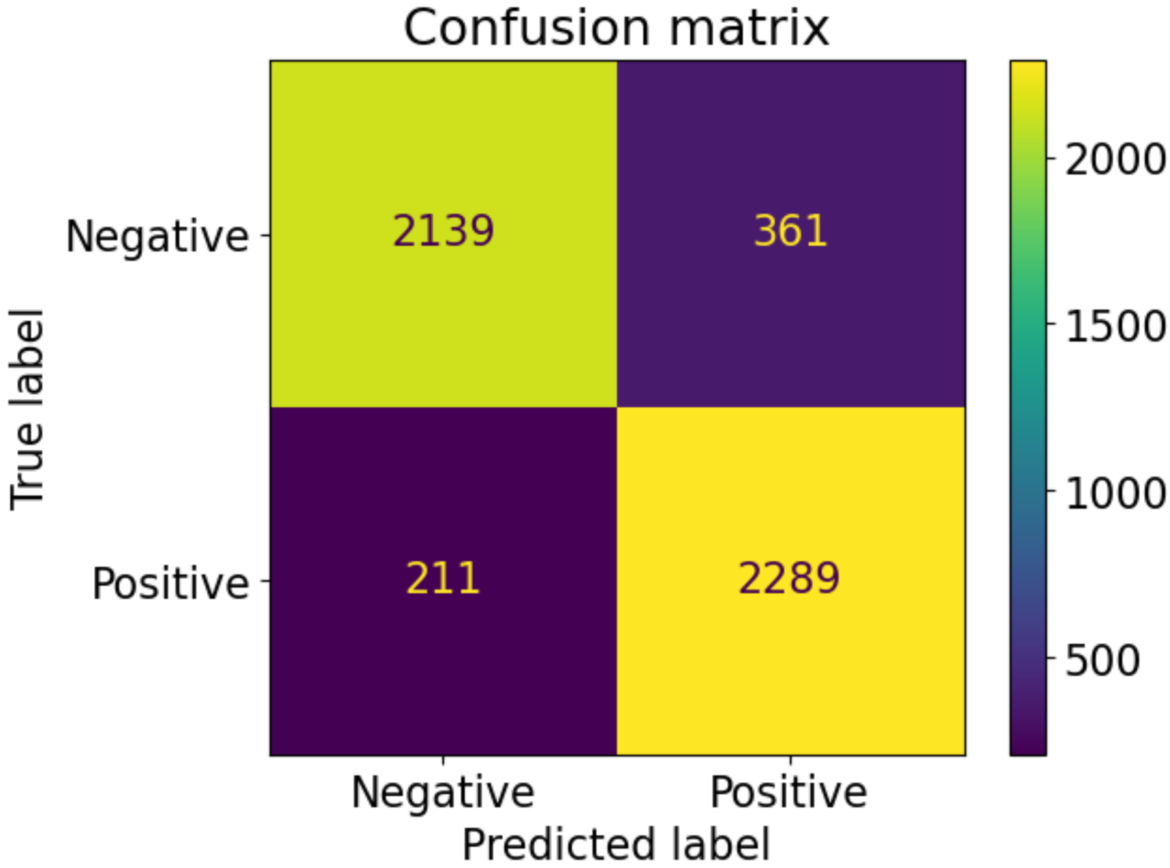
In [18]:
```
plt.figure(figsize = (12,5))
plt.subplot(1,2,1)
plt.plot(H.history['accuracy'], label = 'Train')
plt.plot(H.history['val_accuracy'], label = 'Validation')
plt.legend()
plt.title('Accuracy')

plt.subplot(1,2,2)
plt.plot(H.history['loss'], label = 'Train')
plt.plot(H.history['val_loss'], label = 'Validation')
plt.legend()
plt.title('Loss')

plt.show()
```



In [19]:
```
from sklearn.metrics import classification_report, confusion_matrix
y_pred_proba = model.predict(test_pad)
y_pred = np.array([0 if proba < 0.5 else 1 for proba in y_pred_prob

print(classification_report(y_test, y_pred))

print('\n')

print('Balanced accuracy score: ', np.round(balanced_accuracy_score

print('\n')
cm = ConfusionMatrixDisplay(confusion_matrix(y_test, y_pred), displ
plt.figure(figsize = (5,5))
cm.plot()
plt.title('Confusion matrix')
plt.show()
```

```
157/157 [==============================] - 55s 337ms/step
              precision    recall  f1-score   support

           0       0.91      0.86      0.88      2500
           1       0.86      0.92      0.89      2500
```

```
    accuracy                           0.89      5000
   macro avg       0.89      0.89      0.89      5000
weighted avg       0.89      0.89      0.89      5000


Balanced accuracy score:  0.89


<Figure size 500x500 with 0 Axes>
```



In [ ]: